VOL. IX. No. 3. JULY, 1947

BRITISH HEART JOURNAL

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AUTHORISED BY
THE BRITISH CARDIAC SOCIETY

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LONDON
BRITISH MEDICAL ASSOCIATION
TAVISTOCK SQUARE, W.C.1

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ELECTROCARDIOGRAPHIC STUDY OF TYPHOID MYOCARDITIS

BY

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Received March 11, 1947

During the last century the conception of circulatory failure in the course of acute infectious diseases has been subjected to changes in several instances. Circulatory failure of every kind has, of course, a serious influence on the action of the heart itself, and for this reason in infectious diseases it was considered in those early days (1860–95) as heart failure, and the anatomical damage of the myocardium was much investigated, especially by French authors.

A revolution of this conception was brought about by the investigations of Romberg and Paessler (1899); they showed the paralytic effect of bacterial toxins on the vasomotor centre and considered circulatory failure in infectious diseases merely as a paralysis of the peripheral blood vessels, the heart failure being mainly due to the condition of shock from the infection. This interpretation has been widely accepted till our days.

Later it was shown that in a considerable number of infectious diseases electrocardiographic changes can be found. This fact could apparently be related to the previous findings of myocardial damage. Indeed anatomical damage to the heart muscle occurring in a number of infections, especially rheumatic fever, diphtheria, scarlet fever, variola, and more rarely in cerebrospinal fever and other diseases, as well as in typhoid fever which is discussed in this paper, has been described during the second half of the nineteenth century.

Electrocardiographic changes were found in acute infections such as rheumatic fever, diphtheria, pneumonia, scarlet fever, streptococcal sore throat, cerebrospinal fever, typhus, Malta fever, grippal infections, cholera, and epidemic parotitis.

Our own findings in a hundred typhoid cases will be described and discussed here.

Cardiographic Findings

In Egypt typhoid fever is a common disease; in our department there were between 80 and 120 admissions a year. The findings in 254 tracings from 106 cases are reported here; they are to be divided in 3 groups.

Series I (1933–34) 39 cases. In these only one cardiogram was taken some days after the return of the body temperature to normal.

Series II (1940–41) 60 cases. In these several cardiograms were taken (3–7) during the fever period and after the return to normal temperature, a total of 205 tracings.

Series III (1933–34) 7 cases. These were cases treated with chinin-bismuth-iodide. For reasons to be discussed below they are put together in a separate series; there was only one tracing as in series I.

The cardiograms were made with an amplifier electrocardiograph in the three limb leads and in lead IV F. During the period 1933–34 before the standardization of the præcordial leads we took lead IV F with inverted poles; in some cases of this period no præcordial lead was taken. Some technical difficulties arose from the need to take the tracings in

the wards and the unco-operative attitude of stuporous typhoid patients: and during the war the recording paper was of a very unsatisfactory quality, resulting in poor tracings.

Most of the patients suffered from *Eberthella* infection, and some from infection with *Salmonella paratyphi* (Paratyphoid A) or *Salmonella Schottmuelleri* (Paratyphoid B). The diagnosis was clinically certain in all cases and was confirmed by laboratory findings in all but two. Patients with a history or clinical signs of previous heart disease were not included in this report. Table I shows the laboratory findings.

TABLE I

LABORATORY FINDINGS IN TYPHOID CASES

Diagnostic procedure	Eberthella typhosa (T)	Salmonella paratyphi (A)	Salmonella Schott-muelleri (B)	Mixed infection T+B	Totals
Blood culture	6	—	—	—	6
Stool culture	49	1	4	2	56
Agglutination	27	2	13	—	42
Totals	82	3	17	2	104
Clinical diagnosis only					2
					106

If the blood-culture had a negative result, a frequent happening since the patients were admitted to the hospital at too late a stage of the disease, a stool-culture was done and repeated, if necessary; in cases with negative blood- and stool-cultures the agglutination test was made to confirm the diagnosis; consequently all patients registered in Table I as positive stool-culture had a negative blood-culture, and all registered as positive agglutination test had negative blood- and stool-cultures.

Of the 106 patients 7 died in the course of the infection. The causes of death were toxic circulatory failure in 2 cases (1 with acute nephrosis); intestinal perforation in 2 cases; and typhoid myocarditis in 3 cases.

The clinical picture of heart failure in typhoid myocarditis is very different from heart failure in valvular disease in its quick development, and resembles myocarditis in diphtheria in the combination of " forward failure " and " backward failure "; so in serious cases the extreme weakness and apathy, the moist and cold lividness of the skin with low blood pressure and insufficient pulse pressure of the " forward failure " is combined with engorgement and tenderness of the liver, congestion of the lungs, cyanosis, and sacral œdema; the heart sounds are dull and often a systolic murmur is present at the apex; there is always tachycardia, often embryocardia, and sometimes gallop rhythm at the apex.

The less conspicuous the symptoms are in slight cases, the more they fuse with the phenomena of the peripheral circulatory failure at the acme of the fever, and so the more important becomes the cardiogram for the diagnosis.

First we shall describe these findings and afterwards discuss their interpretation. Table II summarizes the frequency of electrocardiographic alterations in our observations.

Changes observed only in leads III and IV F were neglected owing to the dependence of their shape on the position of the diaphragm; so every registered abnormality was present at least in one of the leads I and II.

Columns B and C of Table II include patients with tachycardia or bradycardia only without other findings; since these changes occurred mostly combined with other cardiographic abnormalities, it does not represent the total number with tachycardia or bradycardia.

TABLE II

FREQUENCY OF ELECTROCARDIOGRAPHIC CHANGES IN TYPHOID FEVER

A Normal	B Tachycardia only (over 110)	C Bradycardia only (under 60)	D A+B+C	E Slight abnormalities	F Moderate abnormalities	G Severe abnormalities	H E+F+G	Total
Series I: Electrocardiograms after disappearance of fever								
20	8	2	30	3	6	—	9	39
Series II: Electrocardiograms during and after the fever								
22	1	2	25	10	19	6	35	60
Series III: Electrocardiograms of patients treated with chinin-bismuth-iodide								
1	—	—	1	—	—	6	6	7
Total:								
43	9	4	56	13	25	12	60	106

" Slight " cardiographic alterations included moderate decrease of voltage of the ventricular and final complex, if present in several leads. Of course the classification of " slight," " moderate," and " severe " is somewhat arbitrary, but does not prejudice the conclusions to be drawn.

Table II shows cardiographic changes in a little less than two-thirds of the examined cases, if the tracings were taken during and after the fever period (series II); such changes were present in less than half, if tracings were taken only in the convalescent period; this result agrees with Table III showing that these changes persist only in half of the cases after the end of the fever period.

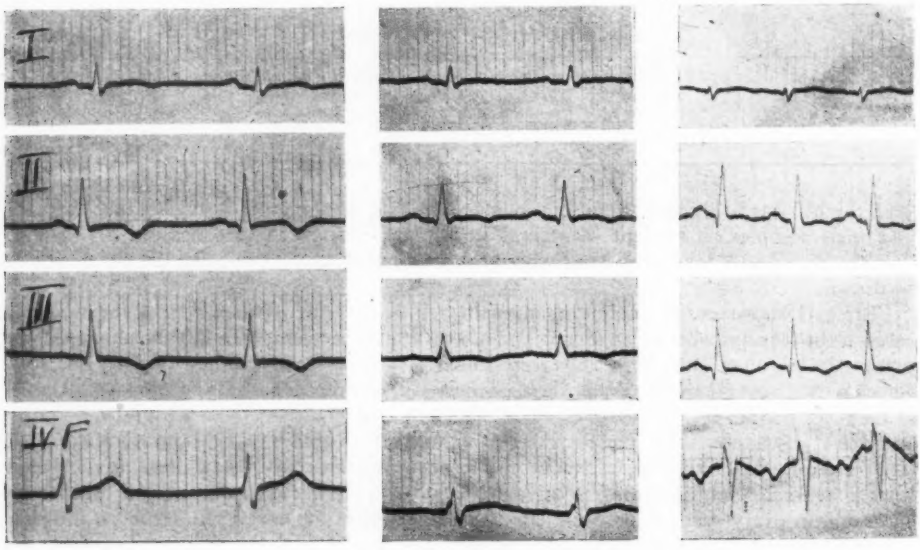
Special discussion is needed for the 7 patients treated with chinin-bismuth-iodide (series III). Here intramuscular injections of chinin-bismuth-iodide in oily suspension were made twice a week, 2–3 ml. according to the age (=0·05–0·075 g. metallic bismuth), a total of 6–8 injections in every case. These patients with one exception developed serious circulatory failure in the course of the typhoid infection; the only exception was a mild case that received only 3 injections. All the 7 presented during convalescence severe cardiographic alterations indicating myocardial damage. We abstain from deciding if there was a causal relation between this treatment and the constancy of heart muscle involvement.

Changes of the final complex were the most frequent abnormality; T was flattened, absent, or negative in two or more leads (changes present alone in leads III and IV F were not considered). Often the S–T segment was below or above the zero-line. The ventricular complex often showed low voltage with slurring or notching. Right or left axis deviation was not infrequent: in several instances we noted a high voltage Q in two leads (leads I and II or leads II and III). Mostly these cardiographic changes occurred together and combined with tachycardia or bradycardia, the latter in young patients with pronounced or sometimes extreme respiratory arrhythmia; there were curves resembling digitalis tracings by the combination of a slow pulse rate (with respiratory arrhythmia) with inverted T waves. A prolonged P–R interval, described elsewhere as a frequent happening in typhoid fever (Porter and Bloom, 1935) was present in one instance only and was not permanent.

In earlier papers the frequency of the different cardiographic alterations is mostly registered by tables. Here in view of the great number we prefer to reproduce the curves of a few illustrative cases.

Case 1. A man, aged 21, with an unimportant previous history was admitted after a six days' fever on 11/4/40 with a temperature of 40° C. (rectal). The pulse rate was 96 a minute. The heart was slightly enlarged to the left, with a systolic murmur at the apex. The spleen was palpable. Moderate anæmia existed: hæmoglobin, 65 per cent (10·4 g.); erythrocytes, 3,900,000; and leucocytes,

7000. In the urine there were traces of albumin; tests for urobilin and urobilinogen were positive. The blood-culture was positive for *Eberthella typhosa*, the agglutination test 1:150. The fever fell after one week to between 38° C. and 39° C. and after three weeks to below 38° C. The heart enlargement to the left increased. The liver became congested and tender. With temperatures about 37·5° C. the circulatory failure increased, the pressure decreasing from 130/55 to 95/75 mm. Neither strophanthine given intravenously nor vasomotor stimulants (caffeine, coramine) nor cortico-suprarenal hormone (percorten) could stop the failure. Death occurred after a 57 days' illness with the signs and the symptoms mentioned above.



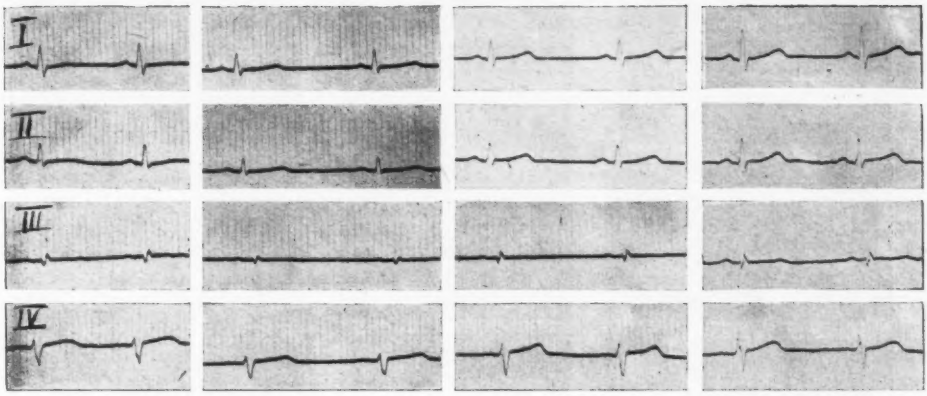
A B C

FIG. 1.—Electrocardiograms of a case of typhoid myocarditis with fatal issue.

	Date	Body temperature	Pulse rate	P–R	R–S (in seconds)	R–T
(A)	19/4/40	38·7° C.	76	0·12	0·08	0·35
(B)	5/5/40	38·5° C.	107	0·16	0·07	0·33
(C)	30/5/40	37·6° C.	156	0·13	0·07	0·23

In Fig. 1A, T is negative in the three limb leads, and deeply in leads II and III. In Fig. 1B, 24 days later, with the increasing pulse rate the voltage of the ventricular complex and of the final wave has diminished; so the T waves are now nearly flat. Fig. 1C, two days before death, shows also a further increase in the pulse rate and the appearance of a Q wave in leads II and III and diminished voltage of R–T. Changes of the lead IV E are not considered in view of the difficulty of replacing the chest-electrode always at the same spot and the influence of the variable position of the diaphragm.

Case 2. A seaman, aged 31, with an unimportant previous history was admitted to the hospital after a six days' fever on 25/7/40 with the typical picture of typhoid fever. There was a rose rash on the skin of the abdomen. The spleen was enlarged. Blood: hæmoglobin, 102 per cent (=16·4 g.): erythrocytes, 5,200,000; leucocytes, 5700. The blood-culture was positive for *Eberthella typhosa*. After one week with a temperature between 39° C. and 40° C. it became subfebrile within the range of 37·5° C. by lysis. Convalescence was uneventful and the patient was discharged on 8/11/40. In the beginning of the disease the heart sounds were very dull, other peculiarities of the circulatory system were not present. Of the series of six curves we have chosen four for reproduction; only the first tracing had been taken during the fever period, the other three during convalescence.



A B C D

FIG. 2.—Electrocardiograms of a case of clinically latent typhoid myocarditis with cure. (Reduced to three-fifths.)

	Date	Body temperature	Pulse rate	P–R	R–S (in seconds)	R–T
(A)	3/8/40	38·5° C.	75	0·13	0·08	0·35
(B)	12/8/40	37·1° C.	65	0·12	0·08	0·38
(C)	21/8/40	36·9° C.	63	0·15	0·07	0·38
(D)	31/8/40	36·9° C.	70	0·17	0·08	0·37

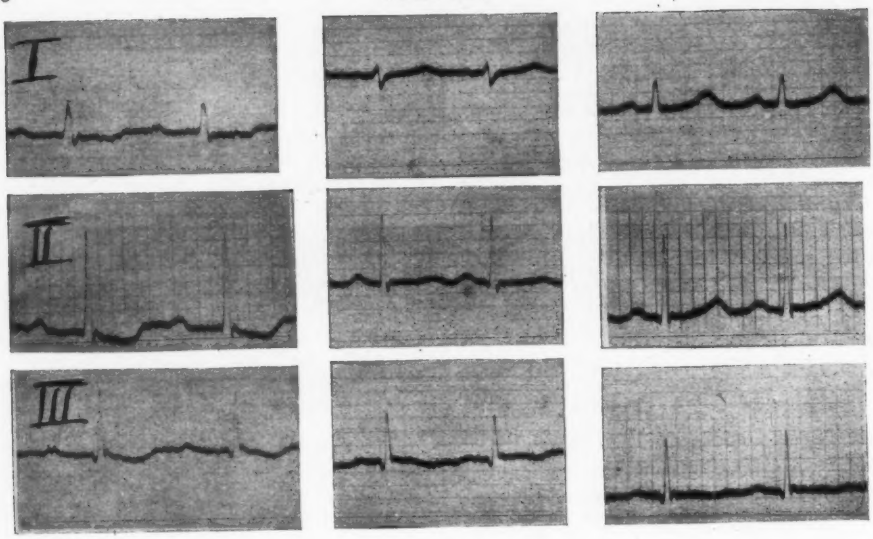
In Fig. 2A, there is a notable flattening of the T wave, which in all leads is only just present; there is also a moderate decrease of voltage of the ventricular complex compared with later tracings. The changes disappeared slowly and step by step. The bradycardia, very pronounced in the beginning, disappeared likewise gradually.

Case 3. A girl, aged 18, with unimportant previous history was admitted to the hospital after a five days' fever (on 15/11/33) with the clinical picture of an exceptionally serious typhoid fever.

The blood-culture was positive for *Eberthella typhosa*. Blood: hæmoglobin, 52 per cent (8·3 g.), erythrocytes, 3,000,000; leucocytes, 6000. The course of the disease was likewise very serious. The fever between 39° C. and 40° C. lasted during two months including two relapses of short duration. After a week's stay at hospital a slight intestinal hæmorrhage occurred. Without peculiarities of the heart itself the circulation was in a critical condition from the beginning for six weeks. At the time of discharge, tachycardia persisted with a pulse rate about 150 after slight exertion. There were three electrocardiograms without præcordial leads (1933).

In Fig. 3A, the T waves are negative in all three limb leads; the S–T segment is below the zero-line in leads I and II. The A-V conduction time is conspicuously prolonged with P–R of 0·23 sec. After a fortnight convalescence with normal temperatures (Fig. 3B) the cardiographic changes had disappeared only partially, the final complex in lead II being abnormal; after a further month (Fig. 3C) the tracing was normal in spite of the clinical instability of the circulation.

Case 4. A girl, aged 12, was admitted to the hospital on 4/12/34 with a fever of three weeks' duration. For one week the fever had ranged between 39°–40° C., but previously there had been subfebrile temperatures. Before the admission to the hospital a blood-culture was positive for *Salmonella Schottmuelleri* (*Paratyphosus B*). The course of the disease was uneventful with a month of fever between 39° and 40° C. During the fever period relative bradycardia existed with pulse rates about 100; in convalescence it rose to 120 and after slight exertion to 140–160 and remained so during three months. During the first 3 weeks after admission the patient received twice a week intramuscular injections of chinin-bismuth-iodide in oily suspension (0·05 g. bismuth per injection). The tracing taken on the fifth day without fever shows notable changes of the final complex. T is negative in the limb leads and the S–T segment in leads II and III is below the zero-line and fused with the initial branch of T.



A B C

FIG. 3.—Electrocardiograms of a cured case of typhoid myocarditis with temporarily prolonged A-V conduction.

	Date	Body temperature	Pulse rate	P–R	R–S (in seconds)	R–T
(A)	9/10/33	38·7° C.	110	0·23	0·07	0·35
(B)	8/11/33	37·1° C.	144	0·13	0·06	0·36
(C)	18/12/33	37·0° C.	134	0·05	0·05	0·28

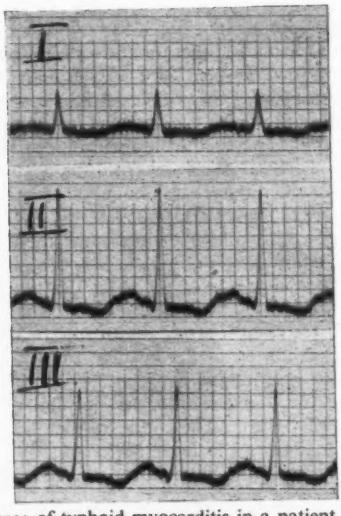


FIG. 4.—Electrocardiogram of a case of typhoid myocarditis in a patient treated with chinin-bismuth-iodide (taken after convalescence).

Date	Body temperature	Pulse rate	P–R	R–S (in seconds)	R–T
9/1/35	36·8° C.	132	0·15	0·06	0·25

The time relation between the cardiographic changes and the infectious fever is not only interesting from the pathological point of view, but is also important for the interpretation of the tracings. The question is, if there is any parallelism between the fever as a measure of the infectious process and the development of cardiographic abnormalities. For this purpose we must examine (1) which is the phase of the infection giving rise to the cardiographic alterations, and (2) whether the changes disappear during the fever or persist after the fever with normal temperatures. Series II of Table II is a satisfactory basis for this examination. Out of the 35 patients in column H, 12 are not considered because of the insufficient number of tracings; this includes 5 fatal cases, 3 of them dying from typhoid myocarditis. In the remaining 23, the abnormal tracings persisted in 18 cases during convalescence; their disappearance lasted mostly from one to three weeks, in some instances even more. Abnormalities persisting indefinitely were not observed. But tachycardia between 120 and 140, especially after slight exertion, was often present many weeks after the recording of otherwise normal tracings. In three cases the changes disappeared during the fever period. In one case there was a complete correlation between the fever and the intensity of the cardiographic changes. In another case they developed only after that the infection lasted, with normal temperatures.

Comment

Electrocardiographic abnormalities in typhoid fever, although in a restricted number of observations, were described by several investigators (Bowe, 1929; Chagras, 1931; Master, Romanoff, and Jaffé, 1931; Lessard, 1933; Porter and Bloom, 1935; and Kiss and Wolleck, 1935). It is known that fever by itself, physically induced, can produce electrocardiographic changes (Vesell and Bierman, 1936; Knies, 1941; Clagett, 1944): these abnormalities, however, are slight.

In typhoid fever anatomical damage of the myocardium is regularly present: as early as in the second half of the last century this fact has been observed by several investigators (Hayem, 1869; Landouzy and Siredey, 1887; Romberg, 1893); cloudy swelling or hyaline degeneration of the myocardial fibres with necrotic foci of microscopic size and infiltration of the heart muscle, interstitial or focal, may be found.

In typhoid fever a shock-like peripheral circulatory collapse exists; in shock, as is well known, cardiographic changes similar to those in coronary insufficiency can occur (Scherf and Klotz, 1944). In our observations, however, the changes persisted longer than the fever and disappeared only slowly during convalescence; in one case they developed even after recovery from the fever. In view of these time relations a causal connection between the peripheral circulatory disturbances and the cardiographic changes cannot be assumed (even if at the acme of the infection the peripheral failure can contribute temporarily to their development).

Vagal stimulation might be a factor in producing changes of the final complex with reference to their combined occurrence with bradycardia (and respiratory arrhythmia); however, the same alterations were found, and even more frequently, associated with tachycardia.

Severe anæmia can also alter the cardiogram (Baugé, 1933; Bloch, 1937; and Szekely, 1940); in our cases severe anæmia was only exceptionally present, and jaundice (Meier, 1940) was seen in only one instance.

In typhoid fever as well as in other infections, anatomical damage of the suprarenal glands is a common finding (Dietrich, 1918; and Dietrich and Siegmund, 1936), and cortical failure has been supposed to be a factor in the development of the circulatory shock: the curves of the Addisonian crisis, however, are very different from those in typhoid fever or in other infections (Delius and Opitz, 1935; and Goodof and Macbryde, 1944); they are characterized by tall, narrow, upright T waves.

Finally B-avitaminosis could be suspected as a factor intervening in the development of typhoid cardiograms, produced by lack of thiamin (Weiss and Wilkins, 1937; Dustin, Weyler, and Roberts, 1939; and Schott, 1944), or of niacin (Feil, 1936; and Mainzer and Krause, 1940). For a long period medical science recommended diets for typhoid fever that were essentially hunger diets; furthermore, it is often difficult to feed these patients sufficiently. In our department a high-calorie diet with vitamin preparations was customary; vitamin deficiency could have occurred only exceptionally.

So the cardiographic alterations in typhoid fever can be referred to the anatomical damage of the myocardium produced by the infection; the tracing is the expression of the typhoid myocarditis.

The myocarditis is the cause of death more often than the diagnosis is made. It is easily overshadowed at the acme of the infection by the peripheral circulatory disturbance; the clinical manifestations of this myocarditis, tachycardia and circulatory instability after exercise, only become manifest in convalescence and persist for a longer time in most cases than the cardiographic alterations.

Summary

The electrocardiographic findings of 106 cases of typhoid fever are described. In 35 of 60 patients cardiographic abnormalities (other than tachycardia or bradycardia with or without respiratory arrhythmia) were encountered during the infection; in 18 they persisted during convalescence; in 1 they developed only in this period. In 12 cases the time relation between the infection and the development of the cardiographic changes could not be observed for technical reasons (lack of a sufficient number of tracings, death during the infection, etc.).

The cardiographic abnormalities take mostly between one and three weeks to disappear (after the onset of the convalescence). Clinical phenomena indicating an instability of the circulatory system (tachycardia) frequently persist for a long time (1 to 3 months) after the disappearance of the cardiographic changes.

Out of a series of 106 patients the cardiograms taken during convalescence were abnormal in 60 instances. Deformations of the final complex were most frequently observed: flat or negative T waves and displacement of the S–T segment. Appearance of abnormal Q waves, development of left or right axis deviation, decrease in voltage, slurring or notching of the ventricular complex were also common findings. In one case a temporarily prolonged A-V conduction was present.

By excluding the possible influences of other factors on the cardiogram (fever, peripheral circulatory failure, suprarenal insufficiency, jaundice, B-avitaminosis) it is shown that the abnormal tracings can be referred to the anatomical damage of the myocardium.

The clinical picture of typhoid myocarditis is described with reference to three fatal cases. The disease is often overshadowed at the acme of the infection by signs of peripheral circulatory failure, escaping diagnosis during the fever period and becoming clinically manifest only during convalescence. The cardiographic diagnosis was made always during the fever period with one exception. The clinical phenomena of the myocardial damage often persist longer than the cardiographic abnormalities.

The author is indebted to Dr. M. Krause for taking the majority of the tracings.

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HEART-VECTOR AND LEADS. PART II

BY

H. C. BURGER AND J. B. VAN MILAAN

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Received May 27, 1947

In a preceding paper (Burger and van Milaan, 1946) we have treated the problem of the relation between the heart-vector and the leads that are usual in electrocardiography. Therein we pointed out that this relation is given by three linear equations, characterized by nine coefficients. The value of these coefficients was determined by means of a model of the human body, a glass phantom filled with an electrolytically conducting liquid. An artificial heart was used to put up an electric current field in the liquid, and the potential differences caused by this field were measured at the extremities L, R, and F.

The human body, however, is not a homogeneous conductor and especially, the lungs, the spinal column, and the liver cause a lack of homogeneity. Further, not only the leads from the extremities are of interest, but the increasing importance of the præcordial leads made it necessary to extend the method to other electrodes as well as to the extremities. The component of the heart vector, directed horizontally from the back to the chest (Y-component) is in this case of preponderating importance. We shall describe an improvement of our former method, allowing for the points mentioned above.

THE NEW PHANTOM

To be able to install the internal organs and to fix the electrodes at different points on the surface of the body, the phantom had to be constructed in such a way that its inner side was within reach. It was of michaplast, that had formed the cover of a small statue of a human being on a scale of 1:3. So it had the normal proportions of a true human body. It was cut into two pieces by a plane parallel to the frontal plane of the body. Of the two pieces the chest-side was the larger one and formed a small basin (Fig. 1) standing on the table, the phantom lying face downward. Arms and legs of the phantom were only short stubs, as the current does not penetrate in them. This part was placed in a large basin, filled with a solution of copper sulphate. The back-side formed a cover, in which holes were drilled to let the air escape. A broad flange prevented the current-field from leaking to the outside.

The artificial heart H consisted of two parallel copper plates of 1·0 cm. diameter and 1·0 cm. apart. The space between was filled with an insulating substance (Burger and van Milaan, 1946, p. 159). It was fixed to a glass tube T, that protruded from the back-cover of the phantom. One heart, with its axis perpendicular to the glass tube, was turnable on a vertical axis, a dial D indicating its direction. Herewith it was possible to set up the component of the heart-vector, perpendicular to the median plane of the body (X-component), or of the component in the direction of its length-axis (Z-component). Another heart gave the component, vertical in the phantom (Y-component). Either heart was placed in the normal position. A potential difference of 4 volts set up the current field inside the phantom.

In addition to the extremity electrodes, L, R, and F, we have used a series of electrodes in different places. Pieces of copper foil of 1–0·5 sq. cm., connected to an insulated wire, were fixed to the inner wall of the phantom in the desired position. The potential difference

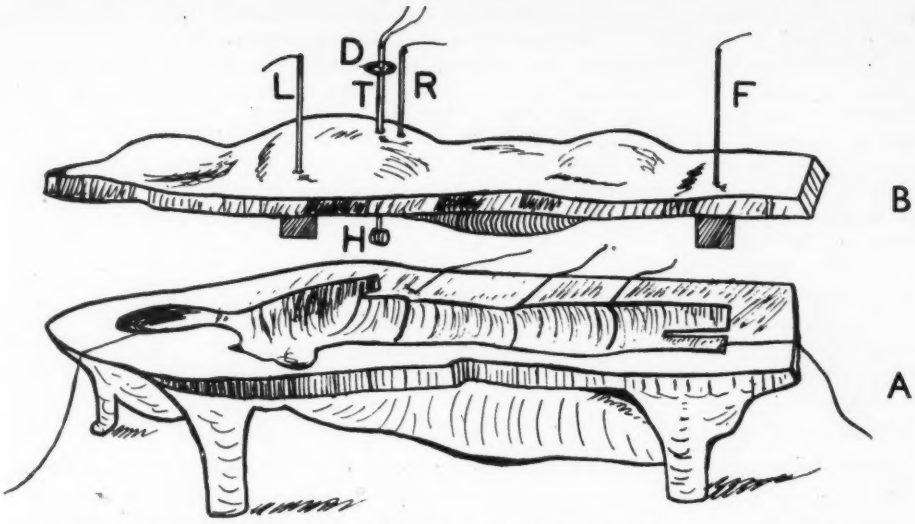

FIG. 1.—Phantom to measure the coefficients in the relation between heart-vector and leads.
(A) chest-side. (B) back-side.
L, R, and F: extremity electrodes.
H: artificial heart with protruding glass tube (T) with dial (D).

between two electrodes was measured by means of a galvanometer provided with a high resistance.

We have asked if the back-cover was essentially necessary. Indeed it proved to be that the potential differences were of an entirely different value if the back-cover was omitted, the heart being placed in the same position. Even if the back-cover was elevated only a few millimetres, the change was perceptible. So we must conclude that measurements with an open basin cannot have any quantitative significance (Guckes, 1939; Hess, 1935; Hollman and Hollmann, 1937; Molz, 1939; and Schellong, 1939).

The lungs in the human body must have a great influence on the current-field of the heart, as their specific resistance is so much greater than that of the other parts of the body: this is a consequence of the air they contain. From anatomical data of the volume of the lungs and physiological data of their air content we have roughly calculated their specific resistance, and that in the state of maximal inspiration, maximal expiration, and in the normal condition. The specific resistance of the lung tissues was supposed to be the same as the average of the rest of the trunk. The result was that the lungs conduct about four times less than that rest.

This ratio can be verified as follows. Formerly we have measured the mean specific resistance of the trunk in the above-mentioned three states of the lungs (Burger and van Milaan, 1943). These specific resistances can be calculated approximately from anatomical date of the trunk, accepting the value of the specific resistance of the lungs, mentioned above.

The substance of which the artificial lungs have to be made must have a specific resistance, four times greater than that of the surroundings. We have found that sand in an electrolytical solution fulfils this requirement. We have, therefore, made two bags of cotton, the shape of which was, as accurately as possible, that of (real) human lungs. They were filled with sand and at their inner sides we have modelled to the best of our ability the hollows for the heart with needle and thread. It was, however, not possible to give them at the foot side the excavation of the pleural dome. The lungs were placed in the chest-part of the phantom.

Some nipples, fixed to its wall, kept the lungs at some distance from it. In this way a conducting layer was left free, just as is the case between the human lungs and the chest wall.

The artificial liver was made in the same way as the lungs. The liver, however, seems to have a specific resistance, depending greatly on circumstances, namely on the fat and blood contents. Our measurements show that the influence of the liver on the relation between heart-vector and leads is only small.

Much greater is the influence of the spine, as it consists of badly conducting bone. The artificial spine was made of cork and was fixed to the back-cover. We have not tried to give it exactly the right shape, but we have given it the average cross-section of the true spine (on a scale 1: 3).

Results

The results of our measurements are all given in absolute units just as in our preceding paper. They hold good for a human body of average dimensions. The potential difference (lead) is expressed in volts, the heart-vector in volts $\times$ cm^2. The coefficients, therefore, in the equation:

$$\text{Lead} = aX+bY+cZ \quad (X, Y, \text{and } Z = \text{components of the heart vector}) \quad . \quad . \quad . \quad (1)$$

are expressed in volt/volt cm^2 = cm^{-2}. They are inversely proportional to the dimensions of the body.

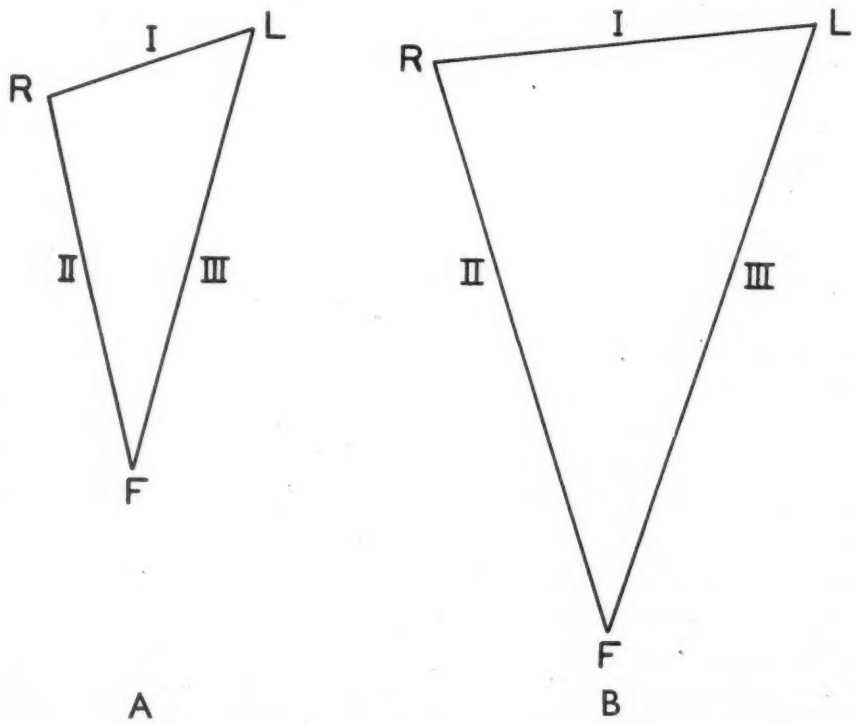

FIG. 2.—(A) Triangle, representing the relation of heart-vector and leads, deduced from a phantom with lungs and spine. (B) The same, without lungs and spine.

The measurement is performed in using an artificial heart giving the components X, Y, and Z one by one. Each time a lead is measured, and from the value of lead and component the corresponding coefficient is to deduce as quotient of lead and component.

Limb Leads

First we have checked our method by measurements of the limb leads of the phantom without internal organs. The result was in accordance with our preceding measurements with the glass phantom.

The influence of the lungs was very marked. The contribution of the horizontal component (X) to lead I especially was reduced appreciably by the lungs. This was to be expected, as the badly conducting lungs at both sides of the heart screen off the current in a direction from the right arm to the left one. The spine did not alter the ratio of the leads appreciably but their absolute values were increased. The liver altered the leads so slightly, that, as a rule, we have omitted it.

The numerical result with the phantom, provided with lungs and spine, is given in the following formulæ:

$$\left.\begin{aligned} \text{I} &= (65\text{X}-21\text{Z}) \times 10^{-5} \\ \text{II}^{*} &= (-25\text{X}-120\text{Z}) \times 10^{-5} \\ \text{III} &= (-40\text{X}+141\text{Z}) \times 10^{-5} \end{aligned}\right\} \quad . \; . \; . \; . \; . \; . \; . \; . \; (2)$$

The mathematical consequence of this analytical relation between heart-vector and leads is that it may be represented geometrically. In Fig. 2A we give this representation, coming in place of the well-known triangle of Einthoven. Fig. 2B represents the relation between leads and heart-vector as found with the phantom without internal organs. The leads I, II, and III are proportional to the product of the projection of the heart-vector on the sides of this triangle and the length of the side on which it is projected.

Præcordial Leads

Up to now we have treated the problem as a two-dimensional one. Only the components X and Z parallel to the frontal plane, were taken into account. But as a matter of fact the problem is a three-dimensional one (Schellong, 1939); the heart-vector has also a Y-component, horizontal and parallel to the medium-plane. We will call it positive if it is directed from back to chest. Fig. 3 gives the situation of the three components of the heart-vector.

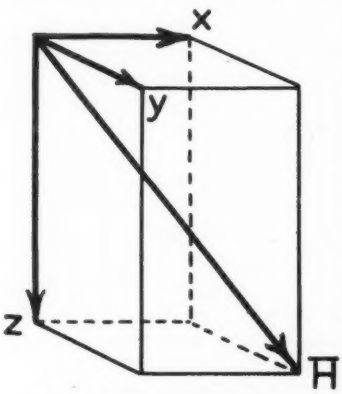

FIG. 3.—Heart-vector $\overline{H}$ and its rectangular components X, Y, and Z.

To find all the three components X, Y, and Z of the heart-vector we need three equations, so we have to measure three independent leads. The extremity leads I, II, and III cannot serve this purpose, as they are dependent, their sum being zero. To get the three independent equations necessary to determine unambiguously the three components of the heart-vector, at least one more electrode has to be used. As such an electrode one of the usual præcordial leads (IV) is suitable. As the position of lead IV we have taken a point in the mammary line and in the fifth intercostal space. We have measured the potential difference between IV and the left foot (F). It appeared to be:

$$\text{IV} = (19\text{X}+30\text{Y}+20\text{Z}) \times 10^{-5} \quad . \; . \; . \; (3)$$

This equation must be combined with two equations for the leads I and II, in which the component Y is

* For reasons of symmetry lead II is given the opposite sign to the usual.

not omitted. These equations are obtained by putting in the equation (2) the term with Y, provided with its coefficient, found with the phantom. These equations are:

$$\left.\begin{aligned} I &= (65X - 17Y - 21X) \times 10^{-5} \\ II &= (-25X - 15Y - 120Z) \times 10^{-5} \end{aligned}\right\} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (2A)$$

From the three equations (3) and (2A), it is possible to solve X, Y, and Z. The result is:

$$\left.\begin{aligned} X &= (12{\cdot}9\ I - 1{\cdot}2\ II + 6{\cdot}4\ IV) \times 10^{2} \\ Y &= (-7{\cdot}0\ I + 6{\cdot}4\ II + 32{\cdot}8\ IV) \times 10^{2} \\ Z &= (-1{\cdot}8\ I - 9{\cdot}0\ II - 5{\cdot}6\ IV) \times 10^{2} \end{aligned}\right\} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (4)$$

Using these coefficients, one can calculate the components X, Y, and Z of the heart-vector from the simultaneously measured leads I, II, and IV.

The equations (2), in which the Y-component is omitted, give an erroneous result for the X- and Z-components, that we will call X′ and Z′. If X and Z are the true values of these components, we can prove that:

$$\left.\begin{aligned} X' &= X - 0{\cdot}21Y \\ Z' &= Z + 0{\cdot}17Y \end{aligned}\right\} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (5)$$

We see, therefore, that the omission of Y gives a rather satisfactory value of the projection of the heart-vector, if its Y-component is smaller than X and Z.

Neglecting the Y-component, from the equations (2) we can deduce an approximate value of the absolute magnitude of the heart-vector during its maximum (R). Assuming for I a value of 1 mV and for II a value of −1·5 mV*) we find that the maximal R-deflection corresponds to a heart-vector of about 2 volt cm².

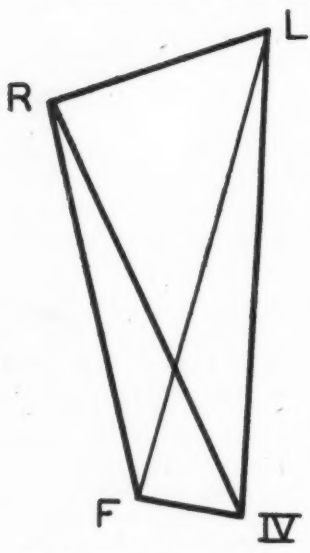

FIG. 4.—Tetrahedron, representing the relation of heart-vector and leads.

Just as in the two-dimensional case, it is possible in the three-dimensional one to give a geometrical representation. Instead of a triangle we have to work with a tetrahedron, the angular points of which correspond to right arm (R), left arm (L), left foot (F), and præcordial electrode (IV) (Fig. 4). Each lead is the product of the projection of the heart-vector on the corresponding edge multiplied by the length of that edge. So if p is the projection of the heart-vector $\overline{H}$ on the edge RL, lead I is equal to $p \times RL$ etc. The shape of the tetrahedron can be deduced easily from the coefficients of the equations (3) and (2A), giving the leads as a function of the components X, Y, and Z of the heart-vector.

To solve the problem of the relation between heart-vector and leads completely, it would be necessary to measure the potential-difference between all the points on the surface of the phantom and a fixed point e.g. the left foot (F), and for the three components of the heart-vector. We do not know if there are leads that are to be preferred essentially above I, II, and IV, nor do we know if there are arguments from the clinical side for using other ones.

We have made some measurements with præcordial electrodes in the median-plane. The origin of the potential-differences was the Z-component of the heart-vector having unit value. Fig. 5 gives the potential difference between these electrodes and F, as a function of their distance

*As II has the opposite sign to usual, it has to be taken as negative.

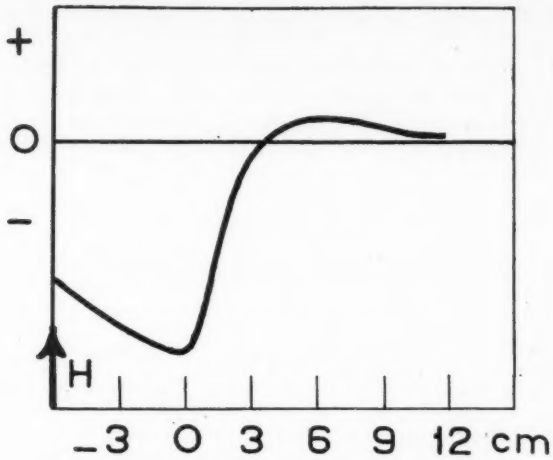

FIG. 5.—Potential difference between præcordial electrodes in the median plane and the left foot (F). The numbers give the distance below the axillary line in the phantom. H=head.

below the axillary line. The point, denoted by H, represents the head, inside which the potential-differences can be neglected. The general type of the curve can be explained theoretically.

Leads that depend on only one Component of the Heart-Vector

In equation (1) the coefficients a, b, and c depend on the position of the two electrodes. It is possible to choose these in such a way that b and c both are zero. Then the lead is only depending on X; it is proportional to X: Lead=aX. In the same way it can be arranged that the leads are depending only on Y and only on Z. Only with a phantom is it possible to find positions of the electrodes that fulfil these requirements.

X-lead. The electrodes are placed respectively in the side, 12 cm. below the axilla and on the right arm. X-lead$=1{\cdot}56\times10^{-3}$X.

Y-lead. The one electrode is placed on the chest wall, 9 cm. to the left of the median plane and 27 cm. below the axilla; the other is placed on the back in the median plane, 27 cm. below the axilla. Y-lead$=2{\cdot}4\times10^{-3}$Y.

Z-lead. The electrodes are placed respectively on the left leg or foot (F) and on the throat 6 cm. to the right of the median plane, at the height of the point of the larynx; Z-lead$=1{\cdot}0^{9}\times10^{-3}$Z.

Only by experience can it be decided if these leads have any practical value.

Short-circuiting of the Electromotive Action of the Heart by the Blood

The value of the heart-vector, deduced by the above method is only an effective one. The electromotive field strength of the heart muscle causes a current not only in the tissue surrounding it but also in the blood inside. As the latter is the better conducting material it acts as a shunt, the outer current being diminished by it (Beleradek and Noyons, 1923). The value, therefore, that is found for the heart-vector is too small. From our measurements with the phantom it is impossible to find the true heart-vector. The construction of the artificial heart leaves this complication out of account.

SUMMARY

The phantom used for the determination of the relation between heart-vector and leads has been improved. It has been provided with lungs and a spine and it is possible to apply electrodes in any desired position. The influence of lungs and spine is appreciable.

The results of the measurements with lead IV and other præcordial leads are given.

It is possible to find leads that depend on only one component of the heart-vector.

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IDIOPATHIC CARDIAC HYPERTROPHY

BY

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Received April 21, 1947

At the beginning of the century idiopathic hypertrophy of the adult heart was commonly accepted as a diagnosis: since then a wider knowledge of the pathology has almost eliminated the term. Similarly in infants and children the disease entity known as congenital idiopathic cardiac hypertrophy is becoming rarer as more underlying causes are brought to light.

The case here described is considered worth reporting because it appears to be an example of one type of infantile cardiac enlargement in which there are no signs of congenital heart disease at birth, but a rapid onset of symptoms and signs of cardiac failure in a previously healthy child, with a gross endocardial and myocardial fibrosis as the striking finding post-mortem.

Case History

V. H. was admitted to Guy's Hospital under the care of Dr. R. W. B. Ellis, at the age of two years nine months. He was an only child of healthy parents and there was no family history of tuberculosis or other important illness.

At birth he was a normal full term baby weighing 9¼ lb. and there was no cyanosis following delivery. Breast feeding lasted for two months and was replaced by adequate artificial feeding including added vitamin extracts. His early development was normal, and he was walking at fifteen months of age. At one year he had pneumonia following measles, since when he had suffered from recurrent bronchitic attacks.

A month before admission he had been an active, healthy child, but for three weeks he had shown signs of fatigue, listlessness, and irritability. Food was often refused and a hard dry cough became noticeable. There was no apparent loss of weight.

On admission he was severely distressed, his face was flushed but the lips were not at that time cyanosed. There was dyspnœa, venous congestion in the neck, and pitting œdema of both ankles.

The apex beat was diffuse and pulsation could be easily felt from the third to the sixth left intercostal spaces and from the mid-clavicular line out to the anterior axillary line. There was no increased cardiac dullness on percussion to the right of the sternum. A blowing systolic murmur was heard at the apex, and the blood pressure was 105/70 in both arms.

A few scattered moist râles and rhonchi were the only abnormal physical signs in the lungs. The liver was enlarged and tender, reaching almost to the level of the umbilicus, but the spleen and kidneys were not palpable. Two days after admission the œdema had increased and there was evidence of a little ascites. Cyanosis was constant and dyspnœa was increased. Venesection of 45 c.c. of blood resulted in an improvement of the general condition.

X-ray screening of the chest showed a heart greatly enlarged to the left and very slightly to the right. A film taken a few days later is reproduced in Fig. 1 (see p. 165).

A blood picture showed a slight hypochromic microcytic anæmia and a normal white

count. A glucose tolerance test, done with the object of excluding glycogen disease, was normal and showed no abnormal rise on administration of adrenalin.

The urine showed no abnormal constituents. Ten days after admission an electrocardiogram showed right axis deviation with a wide notched QRS complex (Fig. 2, see p. 165). A Mantoux test was positive to 1 : 10,000.

The subsequent course of the illness, which lasted for nearly five months, was one of partial recoveries and relapses with a general trend towards increasing cardiac failure. During the periods of relapse, in which the patient became almost moribund, there was pyrexia between 100° and 104° F., sometimes swinging in character, associated with signs of localized patchy consolidation in the lungs, particularly on the left side. White cell counts on these occasions showed a polymorph leucocytosis and blood culture was sterile. There was an apparent response to sulphadiazine, and the attacks were considered to be due to localized areas of lung collapse with superimposed infection. Therapy during the illness included digitalis, to which there was little response after the first relapse, and a course of vitamin B_1 as a therapeutic test for beri-beri, which also had no effect. An oxygen tent gave considerable relief during the relapses.

A teleradiogram of the chest taken seven weeks after admission is reproduced in Fig. 3 (see p. 166), and shows an increase in the root shadows and some blurring of the heart outline.

In view of the size and shape of the heart shadows and the positive Mantoux test, suggesting a possible diagnosis of tuberculous pericarditis, a diagnostic paracentesis of the pericardium was attempted during the third month. No pericardial fluid was, however, found.

An alternative diagnosis of primary mediastinal neoplasm was suggested but screening failed to give any definite confirmation.

During the following month the degree of cardiac failure gradually increased and finally a condition of generalized œdema followed by bronchopneumonia supervened and the patient died twenty-one weeks after admission.

Autopsy. (Dr. K. J. Randall, Pathology Department, Guy's Hospital.)

There were numerous sub-pericardial hæmorrhages beneath both visceral and parietal surfaces. The pericardial sac contained about 100 ml. of blood-stained fluid. The heart showed gross generalized enlargement, weighing 290 g. and being of adult dimensions (normal heart weight for a child of 3 years = 60 g.). The greatest thickness of the left ventricular wall was 1·8 cm., the maximum normal for an adult heart being approximately 1·0 cm. Apart from this gross hypertrophy there was considerable dilatation of all the chambers so that the thickness of the contracted heart wall would have been even greater.

The myocardium was of normal colour and firm consistency. The endocardium, particularly of the left ventricle showed marked thickening of the " sugar icing " type. No congenital abnormalities of the heart or great vessels were present. The valves and coronary arteries were normal.

Pleural effusions were present on both sides and the lungs showed early suppurative pneumonia. The mediastinal lymph nodes were moderately enlarged, but there was no sign of any tuberculous focus.

The liver showed gross fatty change and chronic venous congestion. There were 500–600 ml. of straw-coloured fluid in the peritoneal cavity.

No other abnormality of any organ was found.

On microscopical examination, the wall of the left ventricle showed a gross diffuse thickening of the endocardium by fibrous tissue. There was penetration of the fibrous tissue into the myocardium. This fibrosis was confirmed by staining with van Gieson's stain (Fig. 4, see p. 166). No excess of glycogen was seen in sections stained by Best's carmine. There was no excessive lymphocytic infiltration of the muscle and no evidence of hyperplasia of the muscle fibres.

Apart from the terminal suppurative pneumonia in lung sections and confirmation of the fatty change and passive venous congestion in the liver, no significant abnormality was seen in any other section.

Discussion

Kugel and Stoloff (1933) in a review of cases of so-called idiopathic cardiac hypertrophy of infancy and childhood published up to 1933, found from re-examination of the autopsy reports that out of a total of 52 cases, 17 could be regarded as pure idiopathic hypertrophy. Of the remainder, 8 had inadequate autopsy reports and 27 showed various cardiac abnormalities, amongst which endocardial thickening and increased fibrous tissue in the myocardium were common findings. Round cell infiltration of the heart muscle was mentioned as occurring in 4 cases.

In addition they reported in detail 7 new cases which they claimed might have been recorded as idiopathic hypertrophy had not careful histological examination of the heart been carried out. They all showed a similar picture, including thickening of the endocardium and patchy degeneration of muscle fibres with replacement fibrosis. Two of them showed excessive round cell infiltration, and in no case was there any abnormality of the values or the origin of the coronary arteries. An eighth case was added to the series by one of the authors (Kugel, 1939) in which a similar pathology was found and glycogen disease was excluded by special staining.

In these eight cases, the ages ranged from three months to six and a half years, males being affected equally with females. The total length of the history varied from one day to ten weeks and in no case was there any cyanosis at birth. The main clinical features were similar to those of the case here described, namely a fairly rapid onset of symptoms in a previously healthy child, beginning with fretfulness and refusal of food, then dyspnœa, and later cyanosis leading to a death not long delayed. In one of these cases there was a previous history of pneumonia, and cough was a prominent symptom in two. Neither clinically nor at autopsy did these cases suggest a congenital origin, and the features were more consistent with a past non-specific infection involving the heart.

In other recorded cases it has been noticed that the symptoms dated from a severe lung infection (Mahon, 1936, and Lightwood and Court, 1939). In the three cases reported by Neely (1941) the hypertrophy was attributed to an interstitial pneumonitis demonstrated at autopsy. It is interesting that the histological findings in the heart were similar to those mentioned above, the hypertrophy and endocardial thickening, however, being right-sided instead of mainly left-sided, possibly due to increased resistance in the pulmonary circulation.

In one case with a mild degree of coarctation of the aorta, on the other hand, where the cardiac enlargement was considered to be much greater than could be accounted for by this lesion alone, the endocardial thickening was almost entirely left-sided (Levine, 1934). The suggestion of increased resistance in the circulation playing a part in the ætiology has also been put forward by Powers and Le Compte (1938), whose case of a child aged eight months showed enlargement of the left ventricle, apparently almost entirely due to fibrous tissue, as there was no hypertrophy of individual muscle fibres and no evidence of hyperplasia. In cases of hypertension, however, no such endocardial thickening is found.

Glycogen disease has undoubtedly been responsible for some of the reported instances of so-called idiopathic hypertrophy (Ellis, 1935), and only during the last few years has evidence of infiltration with glycogen been looked for post-mortem in such cases.

A specimen of heart muscle from a case described by Carrington and Krumbhaar in 1924 was re-examined after being kept in formalin for many years, when special staining revealed the pressure of glycogen infiltration (Finklestein, 1936). It is possible, in view of the fact that the glycogen is not uniformly distributed throughout the cardiac muscle but only in certain

areas (glycogenica circumscripta) that the condition is a more frequent cause than is at present realized (van Creveld and van der Linde, 1939).

In our case the main clinical features are typical of the majority of cases of idiopathic hypertrophy reported, except that the age of onset is slightly above the average.

Glycogen disease, vitamin B_1 deficiency, hypertension, gross anæmia, and congenital structural abnormalities were all excluded, and the ætiology of the condition of gross cardiac hypertrophy with endocardial and myocardial fibrosis as the main post-mortem finding, remains unexplained.

Summary

A case of cardiac hypertrophy in a child of two and a half years is described, and the steps taken to exclude the known causes of enlargement, including glycogen disease, are recorded.

At autopsy the heart was found to be 290 g., which is almost of adult size; it showed no structural congenital abnormalities but a marked endocardial fibrosis which penetrated into the myocardium. Cases of a similar nature and some suggestions which have been put forward as to the cause of the condition are discussed.

Thanks are due to Dr. Maurice Campbell for his criticism and advice.

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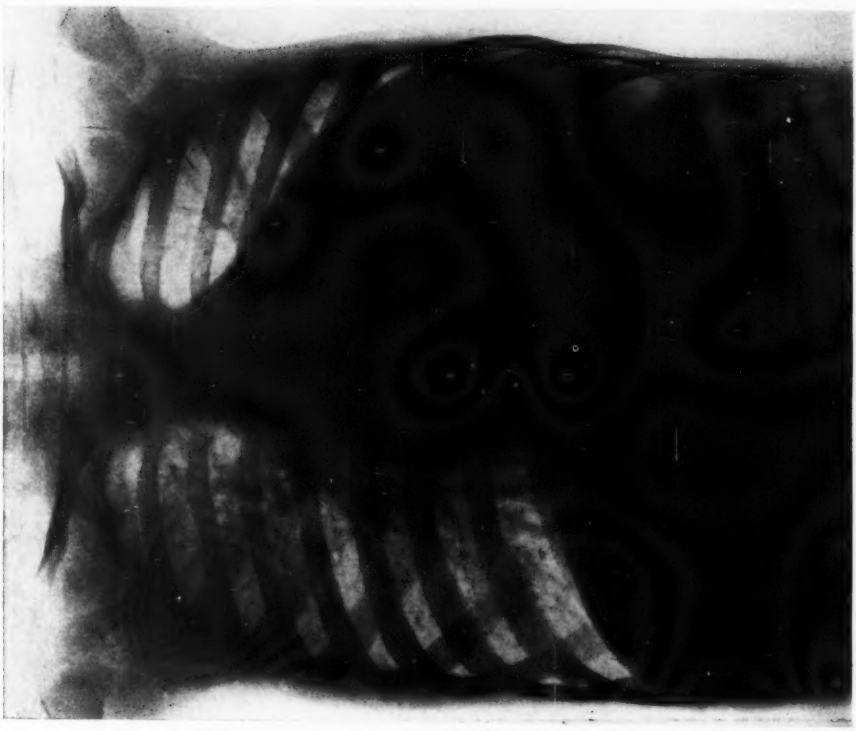

FIG. 1.—Teleradiogram of the heart two weeks after admission, showing gross enlargement of the heart to the left and upwards, and some increase in the root shadows.

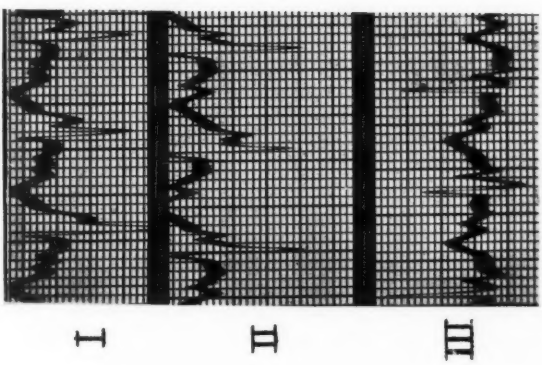

FIG. 2.—Electrocardiogram taken two days after admission, showing right axis deviation with a wide notched QRS complex.

FIG. 3.—Teleradiogram of the heart seven weeks after admission, showing no further increase in size but some shifting of the heart to the right with a considerable increase in congestion of the lung fields on both sides, and some blurring of the outline of the heart.

FIG. 4.—Section of endocardium of the left ventricle, the dark staining parts being fibrous tissue (van Gieson). Magnification: × 46.
(A) indicates myocardium showing fibrosis.
(B) indicates endocardium with gross fibrous thickening.

THE HEART IN SCLERODERMA

BY

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Received May 2, 1947

The following case is of such rarity as to be worth recording in some detail. Although generalized scleroderma, itself a rare disease, may on occasion involve the heart muscle, even if only microscopically, a careful search has shown that only nine examples have been recorded in which the cardiac lesion was gross and directly responsible for death from heart failure. The rarity of this condition is shown by the fact that Weiss (1939) in an article on diseases of the heart and aorta that are not well recognized, in which he described some fifty rare conditions involving the heart, made no mention of scleroderma. In a later paper Weiss *et al.* (1943) recorded nine cases of scleroderma with cardiac involvement, six of which died with generalized congestion. In three of them the cardiac symptoms preceded the skin changes by two years. Among a series of cases which Brock (1934) analysed in an attempt to draw a distinction between dermatomyositis and scleroderma, there was one in which the cause of death was heart failure. Heine (1926) also recorded such a case, and, more recently, Mathisen and Palmer (1947) have published details of one.

Case Report

The patient, a captain in the Merchant Navy, aged 49, stated that since about October 1945 he had noticed his hands and feet had become numb and white on exposure to cold, but quickly improving with warmth. There had been also a very gradual onset, of indefinite date, of muscular weakness and stiffness of his joints, which by May 1946 had become quite noticeable. The weakness was first noticed in the muscles of the calf of the left leg on climbing ladders on board ship, and progressed without remissions to involve successively the thighs, forearms, neck, trunk, and abdomen, till finally he found his jaws became tired when chewing and he would have to pause with food held in his mouth.

At about the time the weakness became pronounced, he began to experience dyspnœa on exertion and swelling of the ankles, and three months later he noticed a sensation of retrosternal constriction, which was brought on by effort and also occurred while in bed at night. The pain on effort was relieved immediately by rest and the pain at rest was relieved by drinking water. He experienced a severe attack of " indigestion " in May 1946. He estimated that he had lost at least two and a half stone in the past year.

Apart from pneumonia in 1931, and in the same year a severe attack of seborrhœic dermatitis, which recurred mildly from time to time especially in hot weather, there was nothing of note in the past history. He had never been frostbitten, had served in the Merchant Navy since 1913, smoked twenty cigarettes a day, and drank moderately.

There was nothing relevant in his family history.

Physical Examination. When first seen early in August 1946 he was of good physique but still somewhat over weight in spite of his loss. The face was blank and remarkably expressionless. The skin looked smooth and shiny with an ivory pallor; the creases were ironed out; the lips were rigid. The facial movements were small and slow and seemed to be made with effort because of the thickening of the skin.

Examination of the cardiovascular system revealed that the heart sounds were distant, the rhythm was regular, the rate was 60, and no murmurs could be detected. There was no jugular engorgement. A small sacral pad of œdema was present. The blood pressure was 120/78. A skiagram of the heart showed a progressive generalized enlargement, particularly of the left ventricle (Fig. 2, see p. 171). In an electrocardiogram on August 20, the P–R interval was prolonged to 0·28 sec., left axis deviation was present, the QRS complex was a little widened and slurred, T I was low, and there was slight depression of the S–T segment in lead IVF. An occasional auricular premature beat was present (Fig. 1A). The respiratory system and central nervous system were normal.

The abdominal wall was remarkably thick so as to give an effect like orange peel, and firm pressure only could produce pitting, which filled up slowly. Neither the spleen nor liver could be felt. The muscles of the anterior abdominal wall were so weak that the patient was unable to sit upright without pulling himself up with his arms. All movements of the arms were weak, and he could not raise them to the back of his head without working his fingers along his temples. Extension of the elbows was limited to 10 degrees, but flexion was unimpaired. All movements of the wrists and small joints of the hands were limited. The skin and subcutaneous tissue were thickened and inelastic, almost brawny in feel, and this was more obvious towards the forearms and fingers, the hands showing the typical appearance of sclerodactyly. The legs showed changes similar to those in the arms. Pulsation in the dorsalis pedis artery was palpable in both feet. The upper edge of the trapezius muscle on both sides was strikingly hard and fixed, resulting in a " hide-bound " effect, feeling almost as though it were carved out of wood.

Progress. On August 26, 1946, he developed suddenly an acute attack of urticaria with much swelling which involved the scalp, face, shoulders, and flexures of the forearm. A papular element appeared and became pustular in the beard area. Four days later gallop rhythm of the left ventricular type was noticed, his lumbar œdema increased, the œdema spread from his legs to his thighs, scrotum, and abdominal wall, and fine moist râles appeared at both lung bases. It was evident that heart failure was coming on rapidly. Bradycardia with frequent extrasystoles and occasional coupling then appeared and persisted in spite of discontinuing digitalis, the pulse falling to 46 and the auricular beat being audible at times. Partial heart block with dropped beats was, therefore, present. By September 16 complete heart block was present, and further flattening of T I and T II had occurred and T IVF had become inverted. Left ventricular premature beats were present (Fig. 1B). On October 14, the pattern was much the same. Complete heart block persisted until death.

During September his urinary output fell and the response to neptal was poor. He was given a neutral diet with low sodium intake and unrestricted fluids, and although his urinary output improved for a few days, he again developed oliguria. On September 30 he began to complain of dysphagia and this continued and became extreme just prior to his death. A fortnight before he died he developed a peculiar mental disturbance consisting of much depression during the day, mainly because he experienced some delay in remembering names of objects, and at night there was much talking and some shouting.

On October 23 a second extremely acute exacerbation of the urticaria occurred and the patient presented an enormous " ballooned-up " appearance, resembling the famous advertisement for " Michelin " tyres. The urticarial rash became hæmorrhagic and serum exuded from the pressure areas and from many other minute excoriations on the trunk and legs. The rigid skin caused extreme pain and discomfort for it would hardly stretch to accommodate the œdema. Morphia scarcely gave any relief and he died the following day.

Treatment. The urticarial attacks were treated with adrenalin and benadryl with no material effect. A penicillin course was tried but was also ineffective. Digitalis for his heart failure was disappointing, organic mercurial diuretics did not appreciably increase the urinary

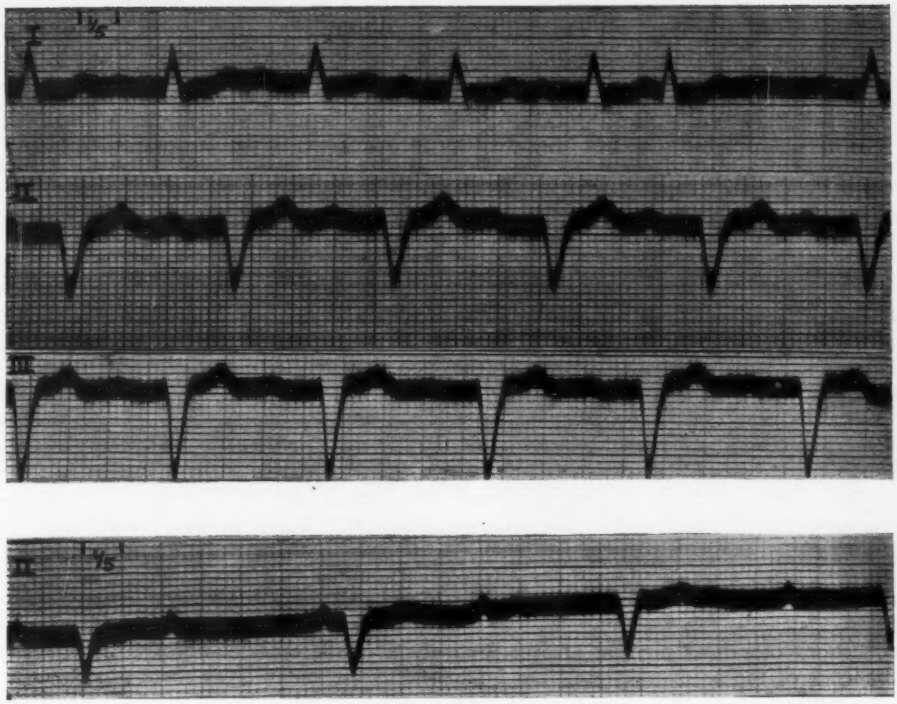


FIG. 1.—(A) Electrocardiogram taken on 20/8/46 showing latent heart block.
(B) Electrocardiogram taken 16/9/46 showing complete heart block.

volume, and although a neutral diet with a low sodium intake appeared at first to increase his urinary output, the effect was very short-lived.

INVESTIGATIONS

Blood Counts. These were repeated on several occasions and showed persistently a moderate polycythæmia and polymorphonuclear leucocytosis. A typical count (August 19, 1946) was: red blood corpuscles 7·56 million per c.mm.; hæmoglobin 130 per cent; white blood corpuscles 12,800 per c.mm. (polymorphs 78 per cent, metamyelocytes 6 per cent lymphocytes 11 per cent, eosinophils 3 per cent, mononuclears 2 per cent).

X-ray examination of œsophagus, stomach, and duodenum, and of forearms, legs, and thighs showed no abnormality.

Chemical Investigations. Fæcal fat estimation. This showed, on repeated examination, an excess of unsplit fat, a typical result (September 17, 1946) being: total fat 27·1 g. per 100 g. of dried fæces; split fat 7·2 g. and unsplit fat 19·9 g. per 100 g. of dried fæces.

Plasma proteins. These were at first (August 10, 1946) normal—7·7 g. per 100 ml. and later (September 28, 1946) fell to 5·66 g. per 100 ml., the albumen being 3·06 g. and the globulin 2·60 g. per 100 ml.

Urinary creatinine. This was persistently raised, for example on August 25–26, 1946, the total daily output was 1590 mg. and preformed creatinine was 1010 mg.

Serum calcium. This was a little low—8·1 mg. per 100 ml.

Post-mortem Examination

Apart from the widespread and characteristic changes due to scleroderma described above there was much anasarca due to heart failure. Watery fluid streamed from the cuts. The skin, subcutaneous tissues, and the underlying muscles were very pale and indurated and cut as though the knife were blunt. The most striking changes were seen in the cardiovascular system. The heart was moderately enlarged (weight: 370 g.) and a small pericardial effusion was present. The ventricles were much dilated. The muscle looked pale brown and lacked resilience. The myocardium cut with the same resistance as the skeletal muscle, and the atrophied fibrous muscle presented an appearance which was striking and best described as "stringy." The heart valves and coronary arteries were normal, and not affected by the fibrosis. The liver showed classical nutmeg changes, the spleen was indurated, cyanotic, and fibrous, and the kidneys were much swollen and indurated by passive congestion.

Microscopic Findings. (Dr. H. A. Magnus.) Pieces of tissue from all organs were submitted for histological examination. All the endocrine glands were normal, except the testis which showed spermatogenesis arrested in the stage of spermiogenesis. The striking changes seen in the heart, subcutaneous tissue, striated and non-striated muscle will be described in detail; the other organs examined, including the pancreas, showed no unusual changes apart from congestion.

Heart Muscle. Six blocks were sectioned from various parts of the heart. They all show a uniform histological picture. Scattered throughout are very numerous areas of fibrosis; the majority of these are small but just visible in the section with the aid of a hand-lens (Fig. 3 and 4). Each area of fibrosis has an irregular outline and the muscle fibres seem to taper away at the edge. Sometimes remains of isolated fibres can be seen in the centres of fibrotic patches. The heart muscle fibres show a considerable degree of brown atrophy, and collections of similar pigment are scattered about in the areas of fibrosis. All the small branches of the coronary vessels are quite healthy; in many areas there is an increased vascularity of the fibrous tissue (Fig. 5). There is no cellular infiltration of the heart apart from small numbers of eosinophils in the fibrous tissue. Sections impregnated by silver for reticular fibres show no new formation of fibrils in the scarred areas. Frozen sections stained by Sudan IV for fat show small quantities to be present in the muscle fibres.

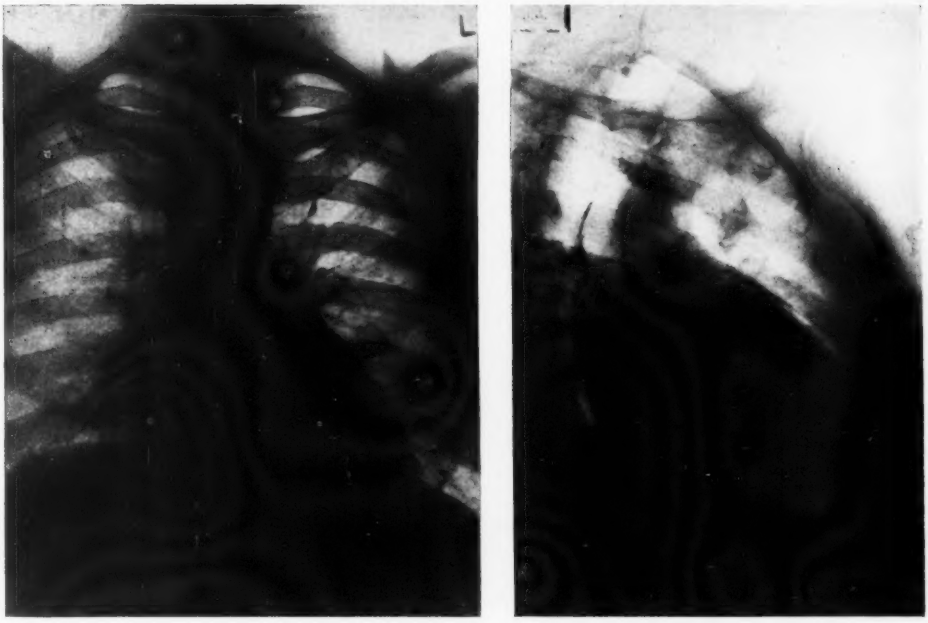
Skin and Subcutaneous Tissue. Apart from some vacuolation of cells the epidermis shows little change, but in all the sections examined there is a striking increase in the amount of collagenous tissue present in the corium. It extends from immediately beneath the epidermis to an average depth of 4 mm. The collagenous tissue is very dense and almost acellular; the blood vessels show no abnormality; the elastic tissue is still present but is fragmented (Fig. 6).

Striated and Non-striated Muscle. The most severe changes are present in muscle from the abdominal wall and the forearm. Here the fibres are undergoing a form of coagulative necrosis. They vary greatly in size and shape; the majority have lost their striations and the cytoplasm is granular; in some areas the fibres have almost disappeared. The nuclei have either disappeared or have been exuded from the fibres. There is a remarkable absence of cellular infiltration in the interstitial tissue and in the sections examined there is no proliferation of collagenous tissue between the muscle bundles. The blood vessels are normal (Fig. 7 and 8).

Similar but less severe changes are present in the muscle of the tongue, pharynx, œsophagus, and intestinal wall.

Discussion

Scleroderma, if it is sufficiently generalized, may on rare occasions be associated with changes in the heart in some degree, but it is exceptional for these changes to be so great as to cause heart failure and death. Only nine such reported examples have been found.



A B

FIG. 2.—(A) Postero-anterior skiagram of the heart, showing generalized enlargement particularly of the left ventricle.
(B) Right oblique view.

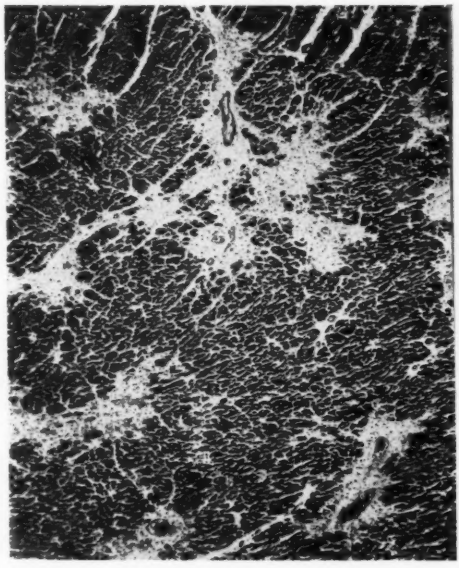


FIG. 3.

FIG. 4.

FIG. 3.—A low-power view of the myocardium showing the numerous small scattered areas of fibrosis. Hæmatoxylin and eosin. Magnification: ×24.
FIG. 4.—An area of fibrosis showing the irregularity of its edge and the absence of any inflammatory reaction. Hæmatoxylin and eosin. Magnification: ×24.

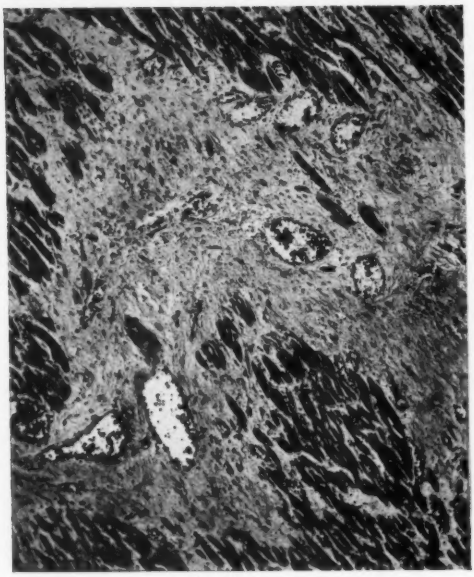


FIG. 5.

FIG. 6.

FIG. 5.—An area of collagenous tissue showing the well-developed blood supply. Near the centre there are several isolated muscle fibres. Hæmatoxylin and eosin. Magnification: ×55.

FIG. 6.—A low-power view of skin and subcutaneous tissue showing the zone of dense fibrous tissue in the corium, and the absence of any cellular reaction. Hæmatoxylin and van Gieson. Magnification: ×21.

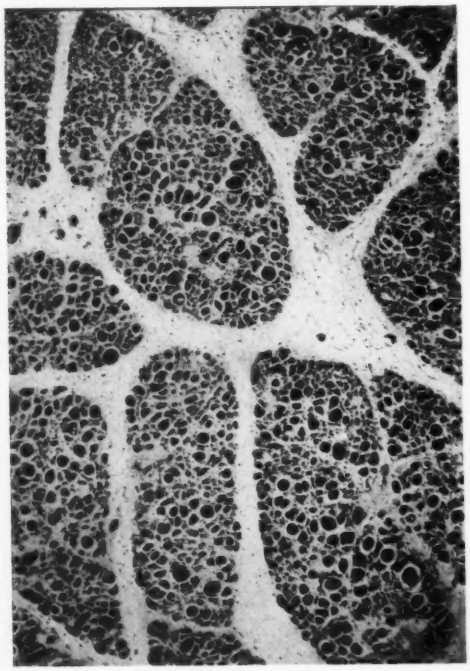


FIG. 7.

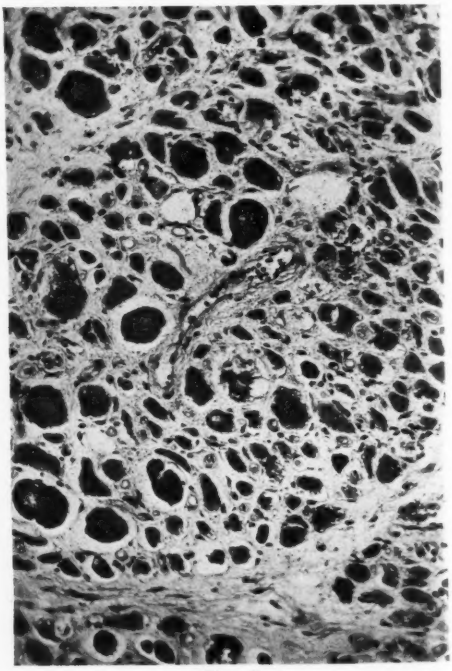


FIG. 8.

FIG. 7.—A low-power view of part of a rectus abdominis muscle showing the great variation in the size of the fibres and the complete absence of cellular infiltration of the interstitial tissue. Hæmatoxylin and eosin. Magnification: ×27.

FIG. 8.—A higher power view of a rectus abdominis muscle showing the structureless appearance of the muscle fibres many of which have almost disappeared. Hæmatoxylin and eosin. Magnification: ×63.

The course of the disease is extremely variable. It may be fulminating, with death resulting in a few weeks, or the progress may be extremely slow or remain stationary for years, death resulting from some other disease. The case recorded died within a year of onset.

The heart almost always fails with normal rhythm, auricular fibrillation having been recorded only once, by Weiss *et al.* (1943). The picture which our case presented was of left-sided failure, accompanied by gallop rhythm, and gradually superseded by right-sided failure, and that is the usual one. Some degree of heart block is common, but this is the first example we can find of scleroderma progressing from partial heart block to complete heart block. With such an interference with myocardial structure, the presence of heart block is not to be wondered at. Considering the amount of cardiac muscle that was replaced by this peculiar fibrous tissue, and that the skin was also heavily infiltrated with it, it is rather surprising that the electrocardiogram deflections were of such good voltage. In a case recorded by Petráček and Šilink (1937) there was simple bradycardia with a pulse rate of 54 a minute. Weiss *et al.* (1943) are of the opinion that the skiagram of the heart in these cases presents a suggestive triangular shape, somewhat resembling the shadow seen in pericardial effusion or sometimes in myxœdema, but the configuration of the heart in our case was in no way typical although there was some selective enlargement of the left ventricle. The impression gained at autopsy, that the enlargement was due to dilatation and not hypertrophy, was borne out by the weight of the heart (370 g.). No organic cause was discovered post-mortem for the dysphagia experienced by our patient, although cases have often been recorded where obstruction could be seen a few centimetres above the diaphragm. It is tempting to presume that the obstruction was neurogenic in origin and that the sensation of præcordial constriction experienced by our patient was of œsophageal origin. Certainly the coronary arteries were unaffected. The patient of Mathisen and Palmer (1947) also experienced mild præcordial pain, which was relieved by rest, and this substernal tightness and constriction recurred a week prior to death and was more evident when she was excited. Weiss *et al.* (1943) consider that the pathological process consists essentially of a primary overgrowth of fibrous tissue, with secondary destruction of cardiac muscle fibres which are infiltrated and pushed aside, and Mathisen and Palmer (1947) also believe that the fibrotic areas encroach upon and destroy the adjacent myocardial fibres. But from study of sections, we are of the opinion that, for some unknown reason, the cardiac muscle fibres disappear in patches and their place is filled up by this new tissue. In Fig. 7 and 8 it will be seen that many muscles fibre are structureless and disappearing, yet there is a complete absence of cellular infiltration of the interstitial tissue. Our conception might be summarized by the title of one of Strauss's tone poems, namely " Death and Transfiguration." This interpretation of the histological picture would explain the complete absence of involvement of even the finest branches if the coronary vessels. The significance of the polycythæmia, which was also present in the case recorded by Petráček and Šilink (1937) but in none of the cases of Weiss *et al.* (1943), is not clear. Possibly anoxæmia might have arisen as a result of the fixity of the thoracic cage which was present; cases have been recorded with radiological evidence of involvement of the lungs, for example that of Mathisen and Palmer (1947), but in our patient the lung fields were clear.

Treatment of the cardiac failure was disappointing, as might be expected from the nature of the process. The presence of excess unsplit fat in the fæces suggested that the pancreas was affected. This biochemical finding has been noted by other observers, and Sellei (1934) has recommended raw pancreas by mouth to alleviate the condition. This was administered to our patient but without effect; microscopically there was no evidence of pancreatic involvement.

Summary

A case of generalized scleroderma is described in which the degree of involvement of the

cardiac muscle was so great as to produce complete heart block and to be directly responsible for death from heart failure. The few other reported cases are reviewed.

We are indebted to Dr. C. K. Simpson for performing the autopsy, and to Dr. H. A. Magnus for the histological report.

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TESTICULAR TERATOMA WITH EXTENSIVE INTRACARDIAC METASTASES

BY

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Received February 2, 1947

Patients suffering from malignant disease rarely die as a result of metastatic involvement of the heart, and the following unusual case is, therefore, recorded.

Case Report

The patient, a male aged 24 years, was admitted to hospital on March 14, 1946.

History. On February 22, 1946, he had acute pain in the left loin accompanied by malaise, sweating, headaches, pain in the chest, and cough with a small quantity of grey, watery sputum. On March 10, his urine was noticed to have a dark colour. On March 12, he had an attack of blurred vision lasting one day, his face became swollen, and vomiting commenced. These symptoms were still present on admission to hospital by which time suppression of urine had been present for more than twelve hours.

Examination. The patient was alert, co-operative, and well nourished. Pulse regular, small, rate 116. Temperature 97·2° F. Respiration rate 30. The sclerae were faintly icteric, and there was generalized swelling and cyanosis of the face and neck. Dilated veins were visible bilaterally running from the thoracic inlet down the arms in the region of the delto-pectoral grooves, but no cervical venous dilatation was noticed. The chest was emphysematous. The trachea was central. Respiratory movements were poor but symmetrical on the two sides. A few high-pitched rhonchi were audible, uniformly distributed over the lung fields. The cardiac impulse was impalpable and the area of cardiac dullness reduced. The heart sounds were faint but otherwise normal, and there were no bruits. The liver was firm, smooth, not tender, and its lower border was palpable four fingers' breadth below the costal margin. A firm fixed mass was palpable deep in the left hypochondrium extending down into the left flank and upwards towards the region of the spleen. Localized tenderness was present over a point in the left sacrospinalis two inches above the level of the iliac crest. Slight pitting œdema was present over both ankles. The urine was a dark brown colour, odourless, and acid in reaction, with a specific gravity of 1030; it contained albumin, bile pigments, and urobilin.

On the morning after admission the sclerae were more intensely icteric and a subconjunctival hæmatoma was present in the left eye. Oedema and cyanosis of the head and neck were more intense and a petechial eruption was present over these areas. On the basis of the above findings the patient was considered to have obstruction of both superior and inferior venæ cavæ. Radiographs of the chest showed a pericardial effusion. Paracentesis pericardii was performed and 750 ml. of icteric serous fluid withdrawn. This had little effect on the condition of the patient who was restless and, at time, irrational. On the morning of March 15, he had an exacerbation of dyspnœa and cyanosis lasting about 3 hours. At 5 p.m. on the same day, his symptoms again increased and by 7 p.m. he was severely dyspnœic and

cyanosed; pulse small, regular, rate 180; respiration 40. Pulsus paradoxus, which had been well marked after paracentesis, was no longer perceptible. The X-ray appearance was unchanged. A further paracentesis was attempted but had to be abandoned on account of the patient becoming severely distressed. His face and neck became almost black from cyanosis, and he died shortly afterwards.

The turbid serous fluid withdrawn from the pericardium contained large deeply staining cells, some of which were binucleate, together with erythrocytes, lymphocytes, and a few polymorphs. It contained 0·8 g. protein per 100 ml. Total leucocytes, 15,000; polymorphs 13,120 per c.mm. Blood van den Bergh gave an immediate direct reaction, with total circulating bilirubin of 5 mg. per 100 ml. Blood W. R. negative. Electrocardiograms showed slight right axis deviation.

Post-mortem Examination

The body of a well-developed, well-nourished muscular young man. The skin showed slight icterus, and the head, neck and upper limbs were livid.

The air passages contained frothy serous fluid. There were 300 ml. of clear fluid in the right pleural cavity and traces of blood-stained fluid in the left. The lungs showed terminal congestion and œdema; no macroscopic deposits of growth were visible.

The pericardium contained about 150 ml. of turbid effusion, and showed fibrinous pericarditis. The heart was enlarged. Both right auricle and ventricle were dilated, and the former appeared, on external examination, to be entirely solid. On opening the heart, the cavity of the right auricle was found to be occupied by a huge cauliflower-like mass of growth which was obstructing the orifices of the superior and inferior venæ cavæ. The growth appeared to spring from the wall of the auricular appendix, the whole thickness of which was infiltrated by growth. The tumour protruded through the tricuspid orifice and a further discrete pedunculated mass sprouted from the wall of the right ventricle (Fig. 1). The myocardium was normal except where infiltrated by growth. The valves were normal.

The liver was enlarged and showed gross venous congestion. The peritoneum was diffusely studded with minute petechial hæmorrhages, and a slight excess of free fluid was present.

A large lobulated mass of growth was present in the lumbar lymphatic glands on the left side. The mass was firmly adherent to the front of the vertebral column and to the left psoas muscle. On section the tumour mass was found to be intersected by bands of fibrous tissue. The cut surface had a variegated appearance suggestive of a solid teratoma, and some compartments of the tumour contained material of a sebaceous consistency. This mass was quite separate from the kidneys and suprarenals. There was a small hydrocele of left tunica vaginalis. The testes were apparently normal on palpation and inspection, but section showed a small nodule 0·5 cm. in diameter in the centre of the body of the left testis.

Histology. Sections of nodules in the testis showed malignant teratoma. The mixed nature of the growth was more apparent in the secondary deposits in lumbar glands and heart (Fig. 2); in the latter much of the growth was necrotic (Fig. 3 and 4).

Comment

There was nothing in the patient's history to indicate myocardial failure or the pericardial effusion as the prime cause of the clinical manifestations. They were adequately explained by the necropsy finding of a large tumour arising from the wall of the right auricular appendix and almost completely occluding the auricular cavity.

In order to obstruct the flow of blood from both venæ cavæ, a tumour must almost completely fill the auricle, so that signs of caval obstruction will be unlikely to appear until a short

time before death, as happened in this case. Œdema of the face from obstruction of the superior vena cava was among the early presenting symptoms, while hepatomegaly was not noticed until the patient's admission to hospital. The liver enlarges rapidly in response to back pressure along the inferior vena cava, whereas a longer time is required for anoxia and local nervous mechanisms to produce manifest œdema. It would appear that obstruction of the superior vena cava was present from the onset of the illness, whereas obstruction of the inferior vena cava occurred relatively late, death intervening before there was time for œdema of the lower extremities to develop.

The purely right-sided situation of the lesion explains the relatively mild degree of respiratory distress despite progressive systemic venous congestion and cyanosis. The acute terminal episode was presumably due to impaction of the mobile portion of the growth in the tricuspid orifice producing complete circulatory obstruction, and a temporary or partial obstruction probably caused the sudden transient increase of symptoms twelve hours before death. It is interesting to compare the results of rapidly progressing right auricular obstruction with those of a similar left-sided lesion. Fawcett and Ward (1939) describe a case with ten months' progressive dyspnœa, cough, and præcordial pain, presenting attacks of faintness and dizziness due to a pedunculated tumour of the left auricle. Wainwright (1938) records cases of both left- and right-sided occlusion. Other examples will be found in the list of references given below.

Yater (1931) lists the " ball valve " type among his anatomical classification of heart tumours. Yater (1931), Fishberg (1930), Lisa *et al.* (1941), and Doane and Pressman (1942) all stress the frequency of sudden death, which may be the first indication of the presence of cardiac tumour.

The post-mortem findings suggest that lymphatic spread occurred early to the para-aortic glands around the renal artery. Thence malignant emboli obtained entrance to the venous blood stream via the cisterna chyli and thoracic duct, there being no macroscopic evidence of the invasion of the inferior vena cava or its tributaries, such as was found in cases of blood-borne tumours of the right auricle described by Paget (1855), Kanthak and Pigg (1897), Parkes-Weber (1915), French (1912), and Fry and Shattock (1926).

The intracardiac metastases probably arose by direct implantation of cells in the wall of the right auricular appendix. Evidence for this is as follows—(1) this region of the auricular wall showed maximal infiltration by malignant cells; elsewhere the cauliflower-like mass lay free in the auricular cavity, following the direction of blood flow through the tricuspid orifice and allowing blood to pass between it and the auricular wall; (2) the tendency towards stasis is maximal in this part of the right auricle as shown by the tendency for ante-mortem thrombi to form here in cases of auricular fibrillation; (3) the absence of pulmonary metastases; (4) the absence of arrhythmia indicating that the sino-auricular node and bundle of His were free from infiltration. Pericardial effusion occurring without obvious cause is a frequent manifestation of a tumour of the heart (Yater, 1931).

Summary

A case of extensive intracardiac metastases from a clinically undetectable testicular teratoma is recorded. The clinical picture is discussed in the light of the autopsy findings and with reference to similar reported cases.

My thanks are due to Professor R. V. Christie and Dr. E. F. Scowen for their encouragement and valuable advice during the preparation of this case for publication. I am indebted to Dr. H. A. Magnus for permission to record the morbid anatomical findings; to Dr. Evan Bedford for bringing a recent monograph on the subject to my notice; and finally to Mr. E. V. Willmott, British Postgraduate Medical School, for the photographic work.

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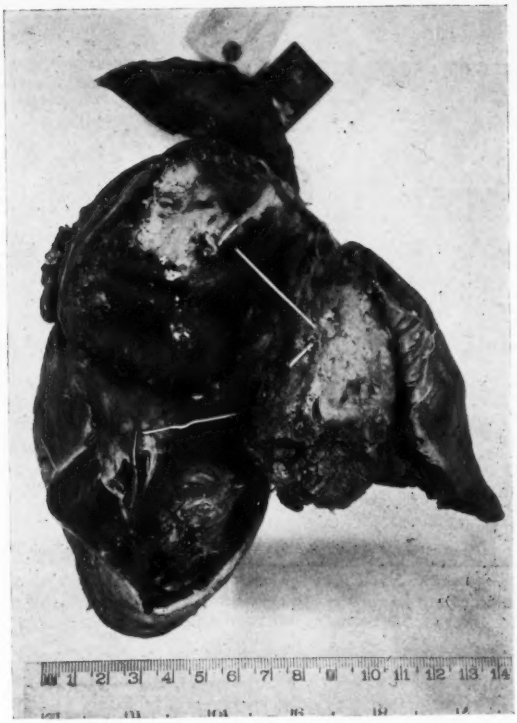

FIG. 1.—Heart with right cavities opened, showing occlusion of right auricle by friable tumour, and discrete nodule of growth springing from wall of right ventricle.

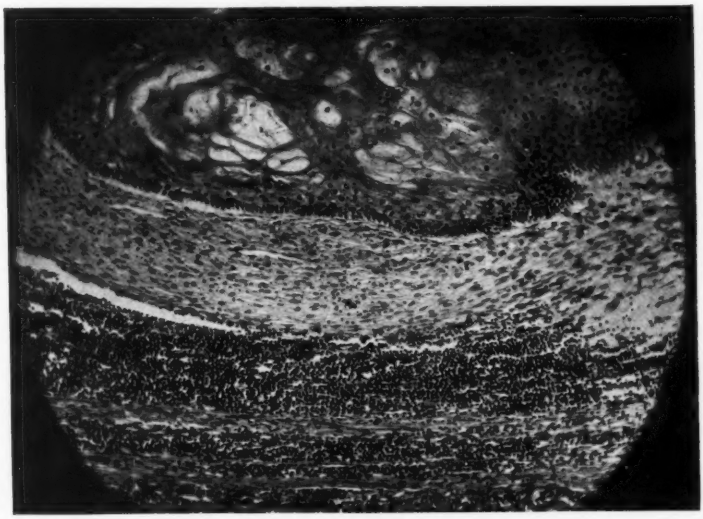

FIG. 2.—Section of lumbar tumour showing epidermal elements. Magnification: × 120.

FIG. 3.—Section of intra-auricular tumour showing extensive areas of necrosis and hæmorrhage. Magnification: × 32.

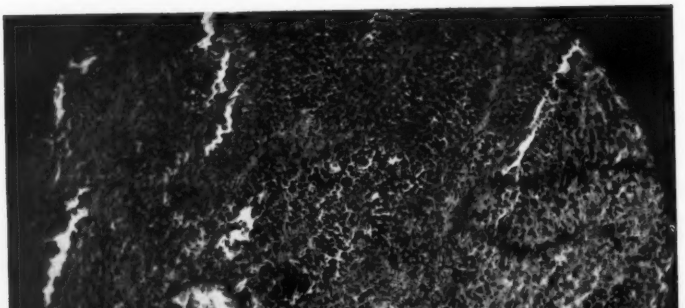

FIG. 4.—Section of intra-auricular tumour. Magnification: × 120.

ERGOTAMINE AND APPARENT CORONARY INSUFFICIENCY

BY

GUNNAR BIÖRCK

From the Second Medical Clinic (Head: Professor G. Nylin), South Hospital, Stockholm

Received June 18, 1947

Since 1942 we have used hypoxæmia tests (Nylin, 1944) as a routine in the clinical examination of patients complaining of symptoms of coronary insufficiency. The results from the first three years' material were reported in this journal (Biörck, 1946). A larger material was investigated (Biörck and Pannier, 1946), and this survey established that the test did not only disclose latent coronary insufficiency in many cases with suspected organic coronary heart disease (" coronary sclerosis ") but also produced apparently pathological electrocardiograms in patients with symptoms of cardiac neurosis in whom there was, on account of their age, very little reason to suspect organic changes in the coronary circulation. The study revealed a relative predominance of women among those who showed a positive hypoxæmia test, and the younger the age group the greater was that relative predominance. There was also a number of cases, mostly women, where the history and the general impression of the patient were suggestive of cardiac or general neurosis.

This impression led us earlier to try to counteract the nervous factors and thus obtain cardiograms that would be less affected by a nervous component. In one case of a possibly climacteric depression we succeeded in abolishing the induced cardiographic changes suggestive of coronary insufficiency by previous injection of morphine-scopolamine.

In a recent investigation Lindgren (1946) has shown that the effect of hypoxæmia on the cardiogram can be diminished in some cases of angina pectoris of the organic type, when the patient has previously received a local anæsthetic at the area of referred pain. This will probably signify that the pain itself, in some instances, induces a vicious circle, and that there is a functional component superimposed upon the organic one, even in cases with true coronary sclerosis.

Although as yet nothing seems to be quite certain regarding the innervation of the coronary vessels (Katz and Jochim, 1939), it may be that both the vagi and the sympathetic carry constrictor and dilator fibres, the distribution of which may be subject to great individual variations. Blocking of the sympathetic was nevertheless regarded as one possible way of studying the problem of the importance of functional factors in some cases of unexpected positive hypoxæmia tests. Nordenfelt (1941) has clearly demonstrated the effect of ergotamine in cases of increased tonus of the sympathetic: cardiograms that suggested coronary insufficiency could in several instances be transformed into normal curves by means of ergotamine, 0·5 mg. intravenously or subcutaneously. These findings have been verified by us in a number of cases.

The cardiographic findings in the hypoxæmia test are usually ascribed to the induced anoxæmia or ischæmia of the myocardium. The degree of myocardial anoxæmia is due to a number of factors such as: ventilation, arterial oxygen tension, and arterial *p*H, as recently shown by Christensen (1947) and Malmström (1947). The findings of Mainzer and Krause (1939) and of Biörck and Pannier (1946) do, however, point to further factors, among which

hormonal influences, reflex mechanisms, and possibly intermediary tissue metabolism should be considered. This study deals with one of these factors—the sympathetic nervous influence. It has hitherto not been possible for us to carry out determinations of ventilation, arterial oxygen tension, and the *p*H of the blood in these cases, and it may be argued that the positive

TABLE I

CLINICAL FINDINGS IN THE TEN PATIENTS

Case No.	Sex and Age	Diagnosis	Blood Pressure	Sedim. rate	B.M.R.	Hæmoglobin %	Organic heart disease *	Neurosis
1	m. 14	Vegetative instability	130/70	1	−2	92	?	?
2	m. 20	Cardiac neurosis? Acute myocarditis?	130/90	1	+4	76	?	yes
3	f. 26	Psychopathia	140/80	3	+7	78	?	yes
4	f. 26	CO - intoxication. Myocardial damage?	110/60	8	+8	78	? *	?
5	f. 26	Cardiac neurosis?	110/80	6	−5	71	?	?
6	f. 26	Cardiac neurosis?	140/70	12	—	80	?	?
7	m. 28	Benzol intoxication. Neurosis	130/85	4	—	82	? *	yes
8	f. 29	Hypercholesterolæmia + Coronary heart disease?	135/80	8	−7	73	yes ?	?
9	m. 35	Subchronic myocarditis?	135/80	17	−2	78	yes ?	yes
10	f. 53	Spondylosis + neurosis + coronary heart disease?	150/100	3	—	77	?	yes

* The electrocardiogram was normal in each case, except that in Case 4 there was a suggestion of myocardial damage or of sympatheticotonia and in Case 7 of vagotonia.

TABLE II

ELECTROCARDIOGRAPHIC FINDINGS BEFORE AND AFTER ERGOTAMINE

Case No.	Original hypoxæmia test			Hypoxæmia test after ergotamine			
	Electrocardiogram		Increase in heart rate percentage	Electrocardiogram			Increase in heart rate percentage
	At rest	Hypoxæmia test		At rest	20 min. after ergotamine	Hypoxæmia test	
1	normal	positive	40	normal	the same	negative	33
2	normal	positive	30	normal	the same	negative	45
3	normal	positive	33	normal	the same	negative	4
4	normal	positive	33	normal	the same	negative	7
5	normal	positive	50	normal	the same	negative	45
6	normal	positive	50	normal	the same	negative	25
7	normal	positive	50	normal	the same	negative	33
8	normal	positive	40	normal	slightly improved	*positive*	75
9	normal	positive	15	normal	slightly improved	negative	30
10	normal	positive	60	normal	slightly improved	negative	50

" Normal " denotes an essentially normal curve.

The increase in heart rate in the hypoxæmia test at the ergotamine test refers to the curve after ergotamine, not to the curve at rest before ergotamine.

The expression " improved " refers to changes in the shape of the cardiogram within the normal limits.

hypoxæmia tests have been due in all cases to hyperventilation. Although this may have been the cause in some instances it is hard to see how ergotamine could abolish this effect.

The material comprises 10 cases, 4 men and 6 women. Most of them were rather young. Two of them had a slight tendency towards transient hypertension, otherwise there was none with evidence of organic heart disease. Most of them were neurotic or showed a vegetative lability (see Table I). They were submitted to routine cardiographic examination and recommended hypoxæmia tests. Apart from one case (Case 4), whose cardiogram was earlier regarded as indicating either myocarditis or sympatheticotonia, all the curves were normal.

The hypoxæmia test was performed with 9 per cent oxygen in nitrogen for 10 minutes and evaluated according to the criteria of Levy *et al.* (1941). These 10 cases were selected for ergotamine-hypoxæmia on account of the apparent discrepancy between the age or the history and the result of the test. They were all re-examined with regard to their circulatory system before the procedure, because of the danger of unfavourable reactions, if the patient should have an organic lesion of the coronary arteries (Lindgren, 1947). Only in one case did we encounter any complication with the ergotamine, probably on account of injection into a nerve.

The interval between the first hypoxæmia test and the one with ergotamine has varied from a few days to one month. However, in no case has there been any change in the patient's condition, subjectively or objectively or any special treatment. The cardiogram at rest has in all cases remained essentially the same.

The ergotamine hypoxæmia test has been performed as follows. After a previous curve at rest the patient has been given ergotamine 0·5 mg. (Gynergen, Sandoz) intramuscularly or subcutaneously. After 20 minutes a new cardiogram has been taken, after which the hypoxæmia test has started. After 10 minutes a third curve has been taken and the patient given 100 per cent oxygen to breath. Two examples are given in Fig. 1 and 2.

The results of each case are shown in Table II. Out of ten cases not less than nine have shown a negative test after ergotamine. This naturally does not mean that there is no change at all, but the changes are within the limits according to Levy's criteria. The one (Case 8), that remained positive, suffers from a moderate cholesterolæmia and has a family history with several deaths from cardiovascular sclerosis in the fourth decade.

The investigation has given some further evidence in favour of the view that nervous influence, presumably over-activity of the sympathetic which is not uncommon in young people, may give a positive hypoxæmia test. The factors that cause positive results can be

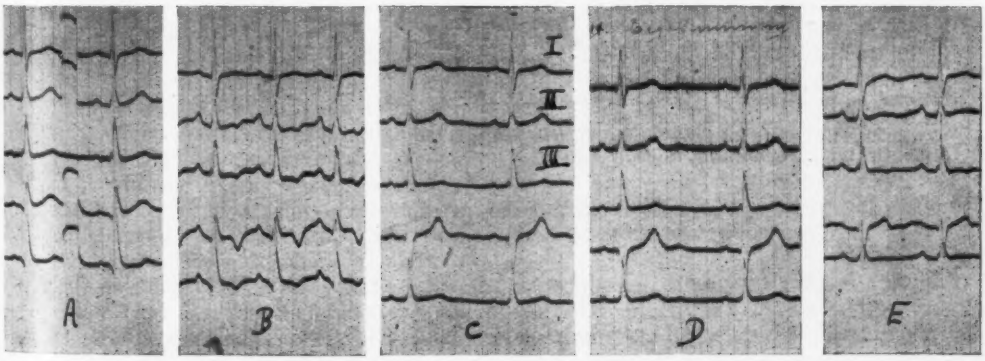

FIG. 1.—Electrocardiograms from Case 1, a boy aged 14, with vegetative instability.
(A) At rest. (B) After ten minutes' hypoxæmia. (C) At rest on a later date. (D) Twenty minutes after 0·5 mg. ergotamine. (E) After ten minutes' hypoxæmia.
The five electrocardiograms are in each case I, II, III, and the anterior and posterior chest leads according to Nylin-Nehb.

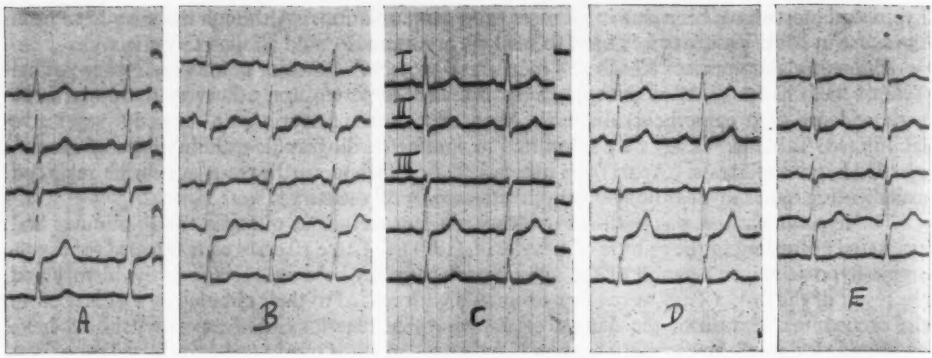

FIG. 2.—Electrocardiograms from Case 2, a woman aged 26 years, with a probable cardiac neurosis. (A)–(E) as for Fig. 1.

partly paralysed by blocking the sympathetic with ergotamine. Endogenous changes in vegetative tonus may naturally also be one explanation. This may express itself also on the ventilation, which should, therefore, if possible, be studied together with the drug action. This study does not attempt to solve the problem of the vegetative activity on coronary circulation, but merely points to its existence and the possibilities of its clinical exploration.

SUMMARY

In ten cases with positive hypoxæmia tests where it was questioned if the outcome of the test might not be due to " functional " factors rather than to coronary sclerosis or myocardial disease, a new hypoxæmia test was performed after the injection of ergotamine 0·5 mg. In nine of the cases the test after ergotamine was negative. This points to an effect of the sympathetic nervous system in such cases. Further investigations are needed.

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COARCTATION OF THE AORTA

BY

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Received May 2, 1947

The collateral circulation in the chest wall, when well-developed, may be the most striking feature of coarctation of the aorta. It was not, however, often recorded by the good clinicians of the past though they had a wide knowledge of the subject in the post-mortem room (Fawcett, 1905). Coarctation is not very uncommon, as hospital post-mortem statistics show that it occurs in about one case in a thousand (Fawcett, 1905, and Evans, 1933, and Blackford, 1926). In spite of this it is still frequently missed probably because in many cases the collateral circulation is not as obvious as it is expected to be, and because the insistence of Lewis (1933) on the importance of the poor femoral pulse is still not remembered often enough.

In infancy, it is rarely diagnosed in life, and in children less often than in adults though the number of reported cases is increasing. This is partly because the blood pressure does not rise greatly for some years and because the collateral circulation does not become evident in the thoracic wall till later. Sheldon (1945) states " a collateral circulation does not develop until about six or seven years of age, but before this the diagnosis can be made with assurance, in the presence of the other physical signs—raised blood pressure in the arms with no femoral pulse and a systolic murmur at the base of the heart."

Our main objects in this paper are to record the development of these changes in some young patients watched over several years, to describe a new sign for demonstrating the collateral circulation, to discuss some theoretical aspects, and to emphasize the points that we think likely to help in the diagnosis.

The cardinal points in the diagnosis are:

(1) A raised blood pressure in the upper half of the body.

(2) Forcible pulsation of the arteries in the neck, sometimes simulating aortic incompetence; this was obvious in 12 of our 15 cases and was sometimes the first suggestion of any abnormality: it should direct attention to the high blood pressure in the arms when this has not been taken as a routine.

(3) Feeble or absent pulsation in the femoral arteries and the abdominal aorta, and a low blood pressure in the legs with a high or relatively high pressure in the arms.

(4) The collateral circulation shown round the scapulæ, on the side of the chest wall, and over the anterior abdominal wall.

(5) The collateral circulation shown by notching of the ribs on X-ray examination.

(6) A systolic murmur (rarely with a thrill) at the base of the heart and often in the back, sometimes with a diastolic murmur.

The diagnosis is most likely to be made in the less obvious cases if the femoral pulse is felt for in every case with high blood pressure, or with obvious arterial pulsation in the neck, or with an unexplained systolic (or diastolic) murmur at the base of the heart. Although the femoral pulse is often difficult to feel, there are as a rule no symptoms of any gross circulatory deficiency in the legs because an adequate amount of blood flows in by devious channels in spite of the absence of a clear pulse wave transmitted directly to the femoral arteries. Symptoms of slight circulatory deficiency may be found on more careful questioning, especially

aching in the legs after marches or long walks. As soon as there is doubt about the femoral pulse the blood pressure should be taken in the legs.

The collateral circulation will be considered first and then the notching of the ribs; next the size of the heart and the murmurs; next the blood pressure and such evidence as we have been able to obtain of the time of development of the rise of blood pressure; and finally the prognosis.

The Collateral Circulation

We wish to describe a new sign for demonstrating this and to bring forward some evidence for the time and rate of the development of the superficial collateral circulation and also of the notching of the ribs from infancy to adult life. The collateral circulation was well studied by early workers and there is a model in the Guy's Hospital Museum from a specimen of Wilks dating from 1859. The subject has been fully reviewed by Bramwell and Jones (1941).

When the collateral circulation is not obvious inspection may fail to show the enlarged and tortuous arteries under the skin. The surface should be inspected from all angles in a good light and the hand passed lightly over all likely positions as in this way a small portion of a pulsating artery under the skin will sometimes be revealed. The patient should also be made to bend forward (see later).

The collateral circulation increases with the years, presumably till it reaches a balance with the demands being made on it. After surgical ligature of an artery the collateral circulation seems to reach its maximum within a relatively short period of months. The much longer period of development with coarctation of the aorta suggests that the need for it increases and this is probably mainly because the actual size of the coarctation does not increase in diameter at the same rate as the rest of the aorta, if at all, so that relatively the degree of stenosis increases until the age when full physical development has been completed.

In all our patients observed over a period of several years increases in the collateral circulation as evidenced by the subcutaneous arteries were noted.

Case 1, aged 7. It was visible and palpable, especially round the scapulæ, when he was first seen. During the next three years it became more obvious, and still more so by the age of 13 when he was last seen.

Case 2, aged 7. There was thought to be some increased arterial pulsation in the scapular regions when he was first seen, but it was indecisive. A year later it had increased and during the next three years it became more easily seen and more widely developed, and possibly again during the following three years, up to 14 years of age. Two years later it was not so easily seen, but this was due to an increase of weight and subcutaneous fat since he had been evacuated to the country. By 1947, when he was 21, it was easily seen both at the front and back of the chest and also on the upper abdomen above the umbilicus, and had increased in the last 4 years.

Case 3, aged 25. No diagnosis was made at 25, but at 28 years there was an obvious collateral circulation over the abdomen and round the scapulæ. She was not seen again for 10 years and it was then extremely obvious in all these sites. It may be that the circulation was not looked for carefully enough when she was 25 but it certainly became more obvious between 28 and 39 years of age.

Case 4, aged 17. The collateral circulation was already well developed. She died later that year.

Case 5, aged 19. The collateral circulation was already easily seen and felt all over the back and up the abdominal wall where the arteries were unusually tortuous and pulsating. Ten years later, when he was 29, additional vessels were seen along both borders of the sternum. He himself thought they had become more visible during these last 10 years and were especially evident when he became heated.

Case 6, aged 13. There were some enlarged arteries round the scapulæ, but they were not very obvious. When he was 22, it had increased and was seen in front along the borders of the sternum. In addition, palpation revealed several vessels that were not visible.

In most of these cases the collateral circulation became more obvious between childhood and adult life and in Case 3, rather surprisingly, it seemed to have increased between 25 and 39 years of age. An increase in weight with subcutaneous fat was important in hiding the collateral circulation and this should be remembered. A hot day or a hot room helped in making it more obvious.

Where the collateral circulation was not very obvious it seemed most likely to be found in the scapular regions. In three (Cases 4, 11, and 13) it was palpable only in the scapular region, and generally palpation was a more sensitive method of detection than observation. In Case 9 the only sign of it that was noted was the notching of the ribs, but we would emphasize that the special method for demonstrating its presence was not used and we have not been able to get in touch with him again.

A New Sign of Coarctation of the Aorta

When this paper had been nearly completed, one of us (S. S.) found that, by making the patient stoop or bend forward with the arms hanging by the side, collateral arteries under the skin of the back and sides of the thorax suddenly appeared where none were visible before.

In two patients (Cases 14 and 15) no collateral arteries were visible on ordinary inspection, but on making them stoop forward, they at once became very prominent, and the diagnosis of coarctation could thus be made on this sign alone (see Fig. 1).

So far the sign has been found in 7 of 8 cases tested and the others have not been available for re-examination. In Cases 2, 3, 5, 11, and 13, the collateral circulation could already be seen, sometimes easily, but it became more prominent on bending forward and became visible in fresh places where it had not been seen before (see Fig. 2).

After the sign had been found positive in three consecutive cases it was hoped that it might be of general application, but in Case 6, where the collateral circulation could already be seen, bending forward did not seem to increase it in any way.

Other changes of posture also caused the collateral arteries suddenly to appear or to increase their prominence, such as forward movements of the shoulders with the arms brought forward. Another good position is for the patient to lie prone on a couch with a cushion under his chest and the arms hanging down over the edge. But the optimum method is by stooping or bending forward with the arms hanging vertically.

The reason for the sudden appearance of these arteries with this change of posture was rather puzzling at first. After discussion with Professor Whillis of the Anatomy Department, Guy's Hospital, he suggested that these particular movements simply widened the costo-clavicular space. It follows that in cases of coarctation where this sign is positive, there must in ordinary positions be a sufficiently narrow space between the clavicle and the first rib to produce some constriction and obstruction of the subclavian artery. Any movement that increases the costo-clavicular space will then relieve this partial obstruction of the subclavian and so the vessels having their origin from the partially constricted artery will suddenly fill up and become larger so that collateral branches previously invisible will become easily seen. Stretching of the skin or gravity or compression of the abdominal aorta do not cause the arteries to show up in this way.

In coarctation of the aorta the subclavian artery is very often dilated and tortuous and so it is quite understandable that some partial compression would occur in the costo-clavicular space. In the cases that do not show this sign the space between the clavicle and the first rib is wide enough not to compress even the dilated subclavian artery. We do not think that compression by the other structures in the costo-clavicular space, such as the nerve plexus or the scalenus muscles, plays any important part.

We have tried to get X-ray evidence for the widening of this space. It has been difficult to find a position where one can take X-ray pictures that will show the amount of widening of the space with the forward position of the shoulders, but we think that in one or two cases stereoscopic views have demonstrated this.

Further evidence that the subclavian artery is partially compressed in the costo-clavicular space is provided by the increase of the radial pulse that follows forward movement of the shoulder or other movements that cause widening of the space.

It is therefore advisable that in every suspected case of coarctation of the aorta, and even in many cases of high blood pressure, this sign should be looked for. The best position is with the patient stooping forward and with the arms hanging down vertically, and the back should then be examined in a good light. By this means we feel that fewer cases of coarctation will escape diagnosis.

Notching of the Ribs

Notching or scalloping of the ribs is almost pathognomonic of coarctation of the aorta though we have seen one suggestive case lately where the diagnosis seems excluded. It was present in every one of our cases examined radiologically though the degree varied considerably. In children it often has to be carefully looked for, as carefully as the collateral circulation, and in younger children it may be absent. Before 1946 we regarded it as perhaps the most decisive point in diagnosis, but increasing experience of feeling the femoral pulse makes us rank this as a more important sign because it can be found on clinical examination and because in children it is present from an earlier age.

Fray (1930) in a note added to his paper says that in one of King's cases there was no visible rib-notching in two films taken when the patient was 10 and 12, but that it had started to show when he was 17 years of age. Brown (1939) states that the youngest recorded example of rib-notching was at 6 years of age. Reifenstein, Levine, and Gross (1947) in a paper dealing mainly with cases that had come to autopsy quote a case of Farris (1935) where there was slight rib-notching in a boy of 11 years, and add that Bland and also Sosman had informed them of cases where they had seen it rather earlier than this. They found it present in 75 per cent of the 43 cases where the information was provided, but in adult cases diagnosed clinically it seems to be present more often than this.

In our Case 1 who was 7 when first seen it was slight but definite. In our Case 2 who was also 7, it was suspected but indefinite; one year later (1934) it could be clearly seen but was still slight (see Fig. 3 and 4). In the case of Rooke (1938), aged 3, there was no visible rib-notching although the collateral circulation was fairly well developed. Neuhauser (1946) has mentioned a case where it was said to be visible in an infant 9 months old, but the next youngest case referred to was 8 years old.

Notching of the ribs obviously depends on the degree of dilatation and tortuosity of the intercostal arteries in their contact with the ribs. In all the 5 patients observed over a period of several years the degree of rib-notching increased. Sometimes the increase is only in the depth of the notching, but sometimes especially in the younger patients the number of ribs affected also increased considerably. The changes were greater in some than in others.

Case 1, aged 7. Notching was slight but noticeable, at first in only 3 or 4 ribs. It had increased by the time he was 9, and again when he was 11 years old. When last seen, aged 13, it was still only moderate (see Fig. 3).

Case 2, aged 7. Notching was suspected on careful searching, but was regarded as indecisive when he was first seen, though looking back at the film and comparing it with later ones it can be seen. A year later it was still slight in degree but was now decisive (see Fig. 4B), and after another three years there appeared to be a further increase. When he was 20, there seemed to have been a further increase from the age of 11, so that in this case the gradual erosion seems to have taken place over a period of many years (see Fig. 4). The number of ribs affected had also increased from 2 or 3 on one side in 1933 to 8 on both sides in 1947.

Case 3, aged 25. The diagnosis was not made till she was 28, though the high blood pressure had been noted at 25. At 28, a suggestion of rib notching was reported, but unfortunately the X-ray film has been lost. Eleven years later, when she was 39, it was well marked in the first 3 ribs on both sides. Here the rib notching and the collateral circulation both seemed to have continued increasing till a later age after the blood pressure had become stabilized.

Case 5, aged 19. This patient showed the least change, but all signs were well developed when he was first seen at the age of 19. Ten years later the notching was a little deeper in one rib and more clear-cut in another (see Fig. 8).

A B

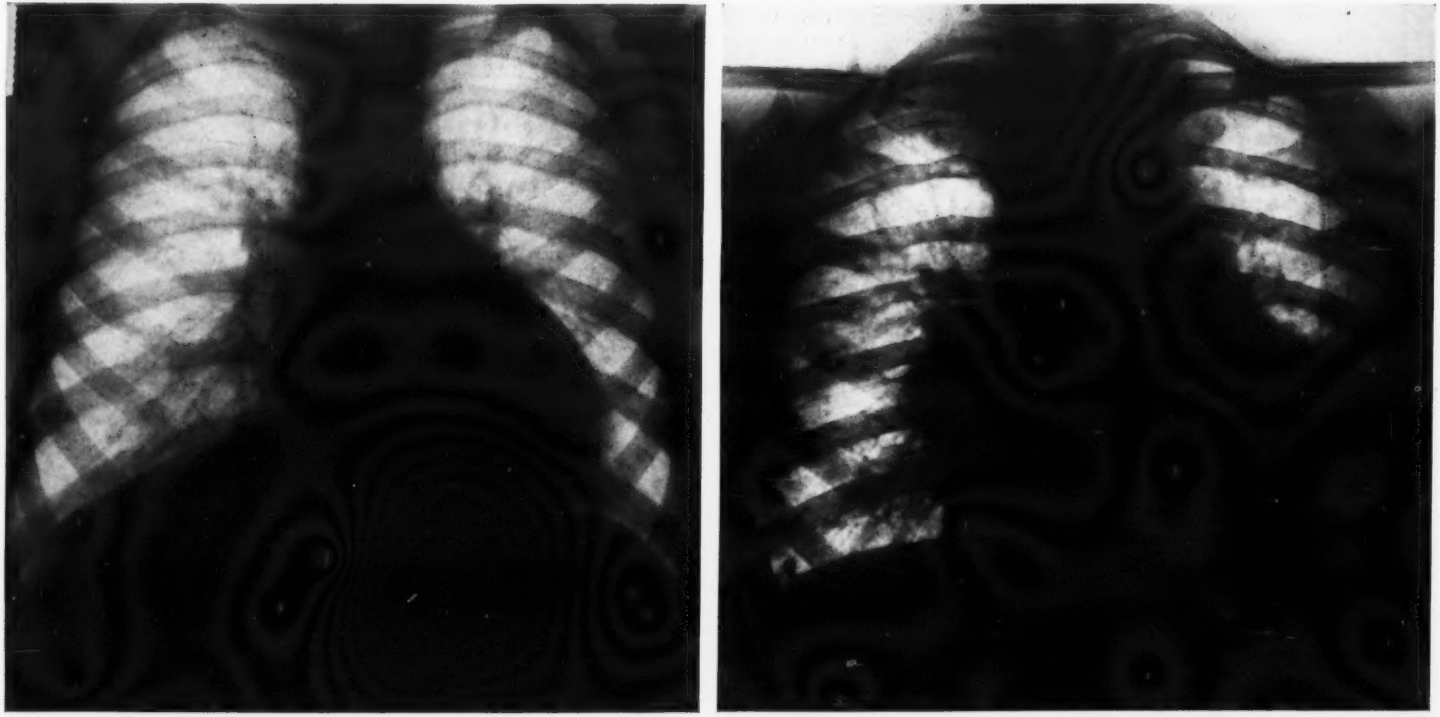
FIG. 1.—The collateral circulation demonstrated by bending forward, in Case 15. The picture in Case 14 was similar.
(A) When standing upright, no collateral circulation could be seen even in a good light.
(B) After bending forward the collateral circulation can easily be seen and there is one specially obvious artery on the right.

A B C

FIG. 2.—The collateral circulation greatly increased by bending forward in Case 2 above and in Case 5 below. (A) When standing upright a few arteries of the collateral circulation can be seen. (B) After bending forward the number of visible arteries is greatly increased. (C) Bending forward a little less than (B), to demonstrate

A B C

FIG. 2.—The collateral circulation greatly increased by bending forward in Case 2 above and in Case 5 below. (A) When standing upright a few arteries of the collateral circulation can be seen. (B) After bending forward the number of visible arteries is greatly increased. (C) Bending forward a little less than (B), to demonstrate

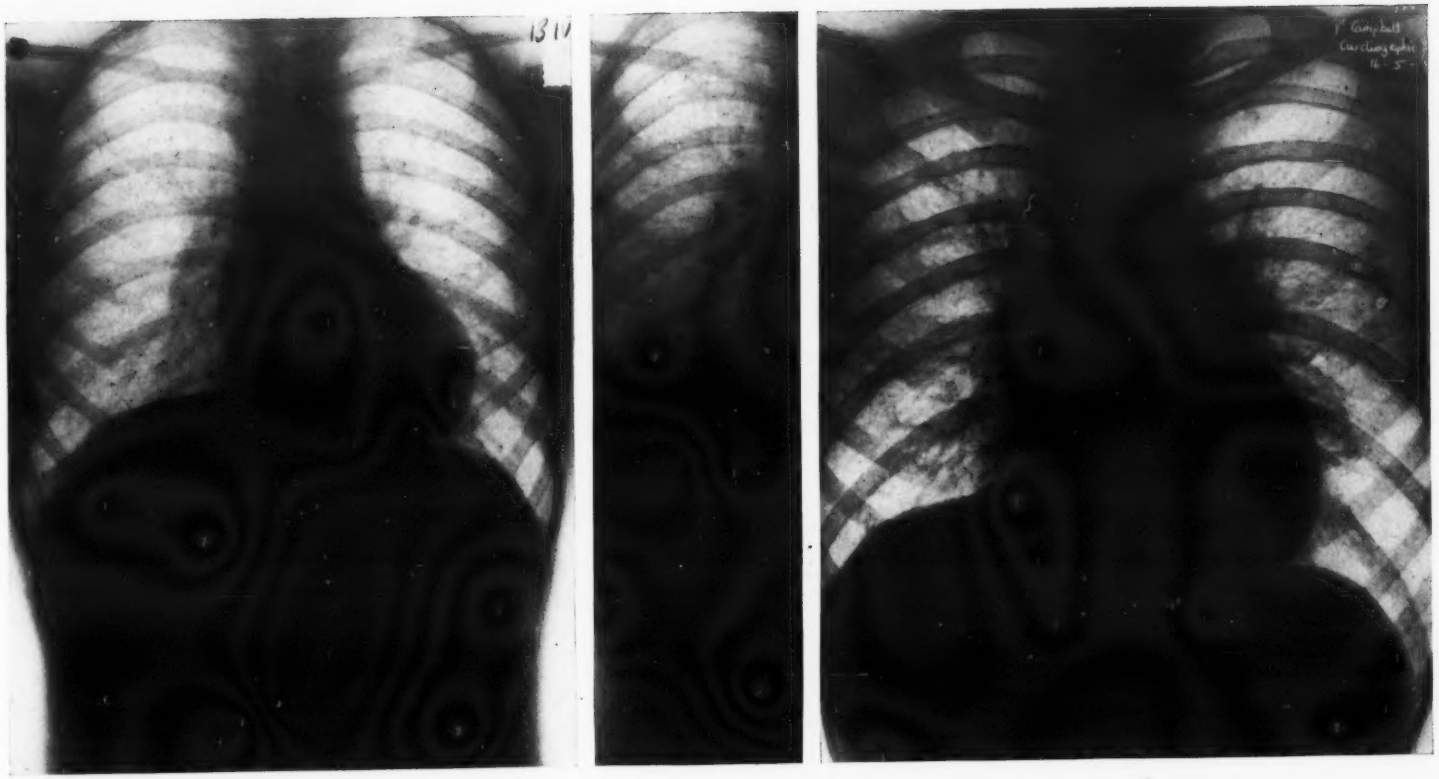


A B

FIG. 3.—The development of rib notching in Case 1.

(A) When aged 7, showing visible but very slight notching. The blood pressure was 142/70 and there was aortic regurgitation.

(B) When aged 11, the notching of the ribs can be seen more easily, especially on the right side. The great increase in the size of the heart is due to an attack of rheumatic pericarditis from which he recovered but was left with further cardiac enlargement (see Table I).



A B C

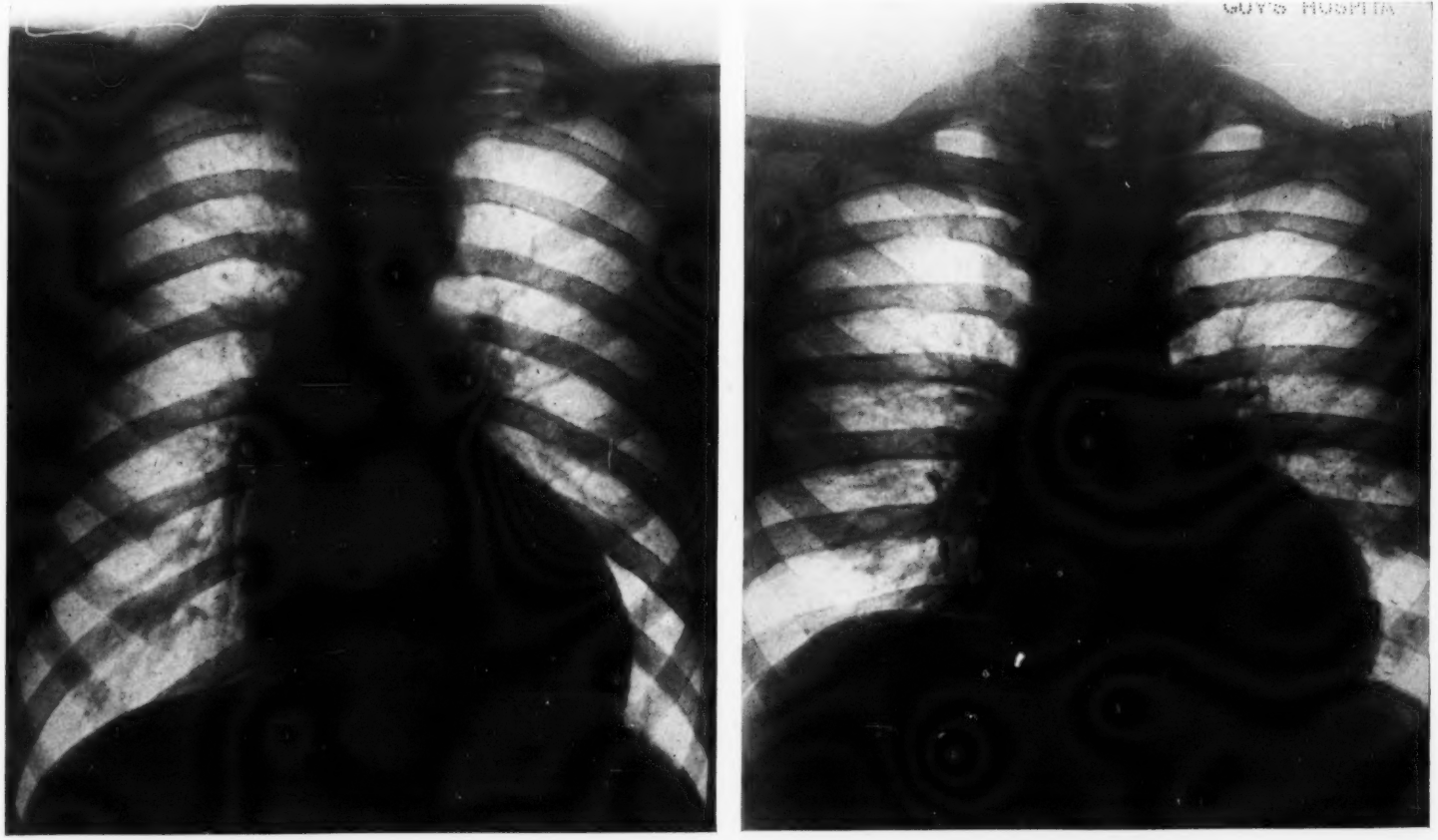
FIG. 4.—The development of rib notching in Case 2.

(A) When aged 7, showing no convincing notching, though it may be suspected.

(B) After 17 months, the right side only, showing slight but decisive notching.

(C) After 13 years, showing increased notching of several ribs on the right and one large clear-cut notch on the left that could not be seen before. The heart has grown but has not increased relatively to the chest.

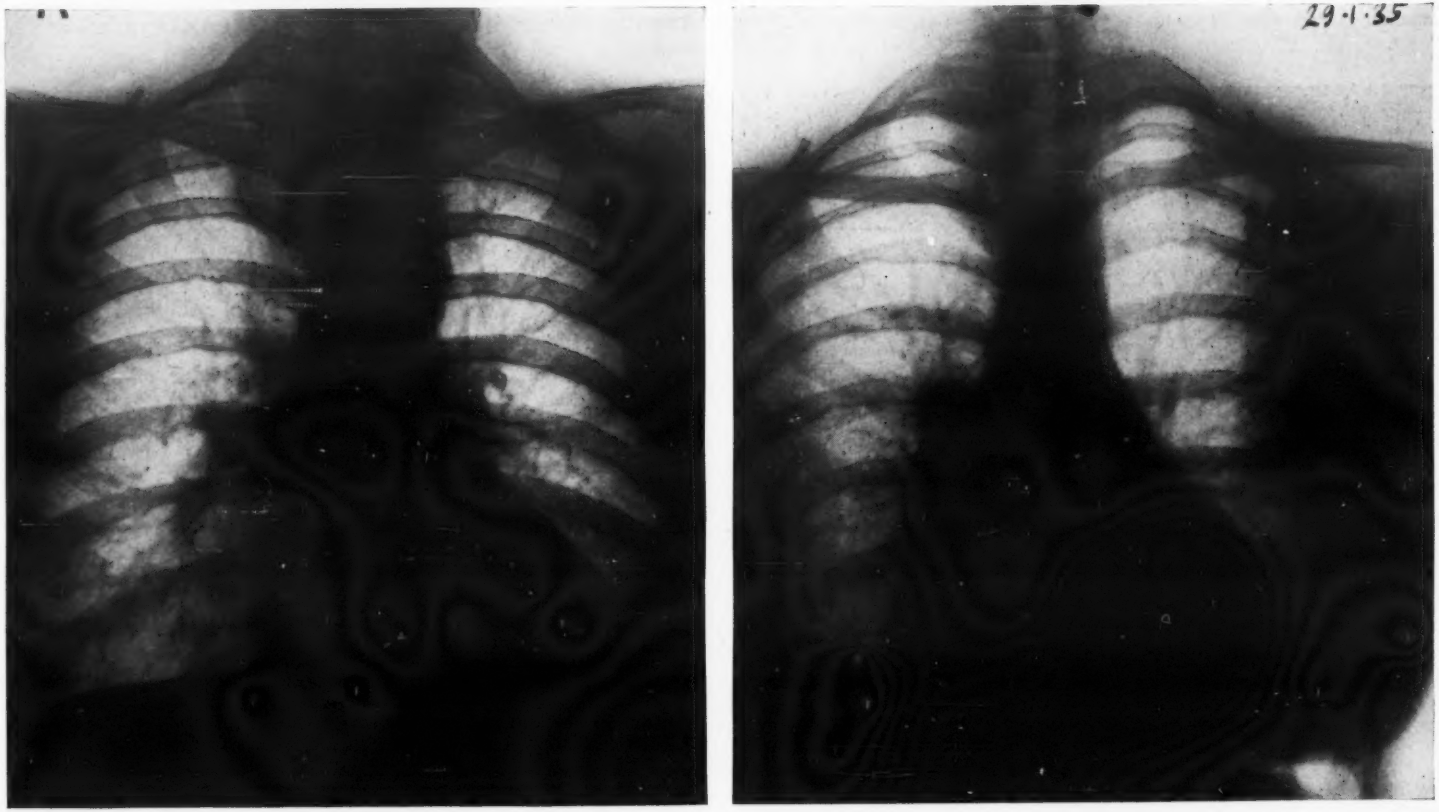
(C) After 13 years, showing increased notching of several ribs on the right and one large clear-cut notch on the left that could not be seen before. The heart has grown but has not increased relatively to the chest.



A B

FIG. 5.—Teleradiograms of enlarged hearts.

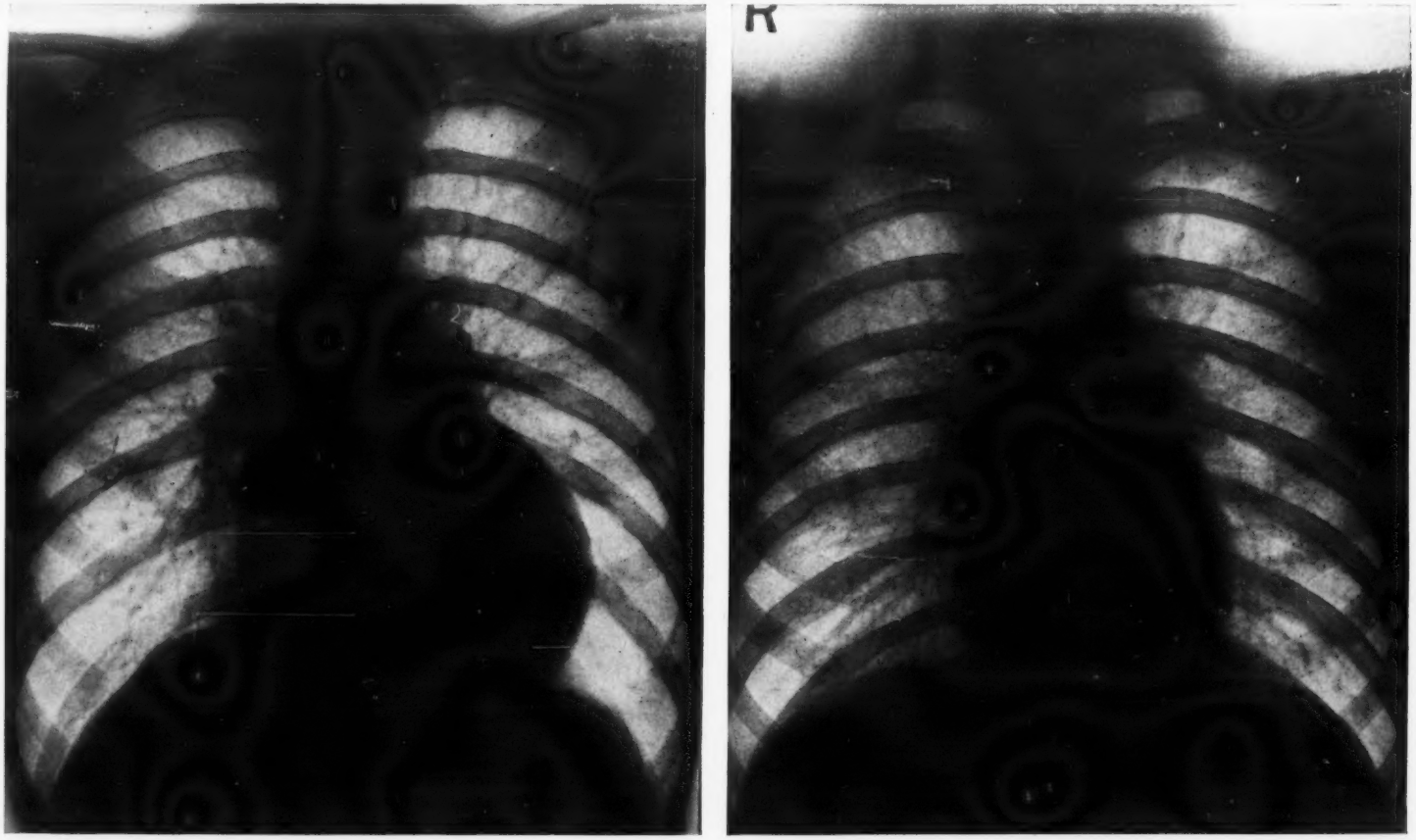
(A) Case 6, aged 22, with an aortic diastolic murmur and a B.P.200/85. (B) Case 13, aged 27, with a B.P.190/100 (165/92 after resting in bed) and no aortic diastolic murmur.



A B

FIG. 6.—Teleradiograms from two women with enlarged hearts. Both show a shadow in the angle between the aorta and the right clavicle, possibly an abnormal origin of the right subclavian artery. (A) Case 3, aged 37, during her third pregnancy. There was no significant change in the size of the heart in 15 years from the age of 25 to 40 years in spite of a blood pressure of 230/120. (B) Case 4, aged 17. Pulsation in the neck was unusually striking; there was free aortic regurgitation with a B.P. of 200/90. On the right the root shadows are increased more than usual and there is a triangular shadow under the clavicle; on the left the border of the aorta is unusually straight. There is a suspicion of notching on the second right rib. The patient died 11 months later, probably of pneumonia but there was no necropsy.

a B.P. of 200/90. On the right the root shadows are increased more than usual and there is a triangular shadow under the clavicle; on the left the border of the aorta is unusually straight. There is a suspicion of notching on the second right rib. The patient died 11 months later, probably of pneumonia but there was no necropsy.



A B

FIG. 7.—Teleradiogram to contrast large and small hearts. (A) Case 11, aged 27, with large rounded left ventricle, a faint aortic diastolic murmur, and a B.P. of 195/100. (B) Case 14, aged 19, with a rather small centrally-placed heart and a B.P. of 165/105.

A B

FIG. 8.—Teleradiograms from Case 5 after an interval of 10 years. In each case the heart was of normal size without evident enlargement of the left ventricle. There is a curved shadow on the right at the level of the aortic arch, and the double curve on the left is well seen. (A) Case 5, aged 19. (B) Case 5, aged 29. The cardio-thoracic ratio is unchanged—10·5/24·5 in 1937, and 11·2/26 in 1947, both being 0·43. This is an example of the least increase in rib-notching over the 10 years.

Case 6, aged 13. Although the blood pressure was already high and did not increase further, rib notching was only slight when he was first seen, the sixth left rib showing suggestive notching. Ten years later, when he was seen again, there were many areas in several ribs on both sides showing obvious shallow notchings (see Fig. 5A).

Dr. W. St. C. Symmers has given us details of a case he saw where the notching of the ribs was not present in a routine X-ray taken when he was 16 (1929) but was obvious when he was 30 years of age (1943). He had no symptoms, but at a routine examination in the Navy he had forcible pulsation in the arteries of the neck, some enlargement of the heart, systolic and diastolic murmurs widely conducted from the base, and a blood pressure of 195/95 (right arm), 185/95 (left arm), and 105/75 in the leg. No pulse could be detected in either femoral artery. The X-ray of 14 years before was obtained and no notching or enlargement of the heart could be seen. In 1940 he had been examined by the Naval Mass Radiography Unit without comment, and the radiologist who re-examined it in the light of the subsequent findings said that it showed no abnormality.

Thus in all the cases followed for some years from childhood or early adult life, there was an increase in the depth of the notching or in the number of ribs affected or in both, though no doubt a stage is reached—later than the stabilization of blood pressure or even the development of the collateral circulation—when there is no further increase in the erosion of the ribs.

There seemed to be no correlation with the blood pressure, the murmurs, or the size of the heart, and only a limited correlation with the extent of the superficial collateral circulation, the notching of the ribs continuing to increase to a later age. Other points, especially the site and distribution of the notches and the mechanism of their production have been dealt with by Bramwell and Jones (1941): they state that it does not occur on the second rib but we think we have seen it there once, perhaps due to an abnormal artery (see Fig. 6).

The Size of the Heart

Lewis (1933) pointed out that there might be no progressive enlargement of the heart over many years and stated: " Cases do occur and are not infrequent in which with very high blood pressure the heart presents no sign of enlargement clinically even when examined by means of X-rays. It is improbable, however, that increased weight of the heart can be excluded by these means." And, in fact, Peacock (1860) found the heart generally enlarged in 18 of 40 cases, while in 10 others there was a moderate increase affecting chiefly the left ventricle, and Abbott (1928) found some enlargement in 154 of 200 cases where there was necropsy evidence.

It is clear, however, that high blood pressure in coarctation of the aorta does not produce as much enlargement as might be expected. Judged by the cardio-thoracic ratio many cases would be said to have no enlargement; but some degree of hypertrophy of the left ventricle seems usual though not constant as judged by the rounded contour of the left border of the heart (see Fig. 4, 5, and 7). Where there is much enlargement additional causes should be suspected, such as associated congenital defects, the development of aortic regurgitation often on the top of congenital bicuspid aortic valves, or secondary changes in the heart muscle, which in the cases of pure high blood pressure without the associated factors of ordinary hypertension may be delayed for very many years.

Of our 15 cases, 8 showed no enlargement or only a little enlargement of the left ventricle, as shown by some rounding of the left border, and 7 showed this in a more developed form so that there was some general increase. The maximum transverse diameter and the size of the chest for all our cases are given in Tables I and II.

Of the 7 with enlarged hearts, 4 had an aortic diastolic murmur (Cases 1, 4, 6, and 11) so that no doubt this was partly responsible for the increase in size. In the remaining 3 (Cases 3, 7, and 13) aged 25 to 36 years the blood pressure averaged 215/112 (230/120, 250/120,

FIG. 8.—Teleradiograms from Case 5 after an interval of 10 years. In each case the heart was of normal size without evident enlargement of the left ventricle. There is a curved shadow on the right at the level of the aortic arch, and the double curve on the left is well seen. **(A) Case 5, aged 19. (B) Case 5, aged 29. The cardio-thoracic ratio is unchanged—10·5/24·5 in 1937, and 11·2/26 in 1947, both being 0·43. This is an example of the least increase in rib-notching over the 10 years.**

and 165/92 respectively). In the four with diastolic murmurs the readings were 155/68, 200/90, 205/85, and 195/100 respectively (average 189/86, or 200/92 excluding the child).

There are considerable differences in the shape of the heart in coarctation, the only common feature being the left ventricular enlargement present in many cases. The differences in the shadow of the aortic pedicle are even greater and for this reason we have reproduced several films to illustrate different types.

The absence of the aortic knuckle in the radiogram has been emphasized as another classical sign of coarctation. This with a straight left border is well shown in Fig. 3A, 5B, and 6B. In other cases, as Bramwell (1947) has pointed out, there is a striking double curve the upper generally representing the tortuous and dilated subclavian artery and the lower the blind end of the descending aorta (see Fig. 7A and 8). In the paper by Hamilton and Abbott (1928) there are on successive pages a radiogram and a photograph of the specimen post-mortem and the correspondence of the upper curve with the subclavian artery is well shown. Fig. 5A is unusual in looking more like a case of aortic incompetence (which it was) with an apparent aortic knuckle.

In some cases there are unusual shadows on the right; in the angle of the clavicle and aorta, possibly an abnormal right subclavian artery (Fig. 6), and lower down on the right (Fig. 4A). The root shadows are often prominent and were specially so in Fig. 4C, 6B, and 7B.

Two men with enlargement of the heart, especially to the left, are shown in Fig. 5, and two women in Fig. 6; in each case one had and one had not got aortic regurgitation: possibly the shape of the aorta in Fig. 5A is suggestive of aortic regurgitation, but this is not true of Fig. 6B and otherwise the distinction could not be made on the X-ray film. In Fig. 7 another of the larger hearts is contrasted with a smaller one, both from young men of similar size and build.

Of the 8 with little or no enlargement, 4 showed no enlargement clinically or radiologically (Cases 5, 9, 14, and 15; see Fig. 7 and 8). The other 4 showed some rounding of the left ventricle only (Cases 2, 8, and 10; see Fig. 4) or slight enlargement clinically without an X-ray being available (Case 12).

The other 6 with no general enlargement were between 18 and 33 years of age and the blood pressure readings gave an average of 190/108 which is not much below the average figure (215/112) for the three with moderate enlargement of the heart without an aortic diastolic murmur.

It is clear from these figures that in some cases, but not in all, the enlargement of the heart can be correlated to some extent with the presence of a diastolic murmur; but not, at any rate at all closely, with the level of the blood pressure, as this may be just as high in those with no enlargement.

Another point of interest is whether there is any progressive enlargement when the patients are followed for several years. In the younger patients because of the natural growth of the chest as a whole, absolute measurements are not enough and the cardio-thoracic ratio combined with inspection of the contour of the heart is probably the best guide.

In Case 1 the heart did increase in size over 6 years without much development of his chest, but he had aortic incompetence and an attack of rheumatic pericarditis (Fig. 3). In Cases 2 and 5 (Fig. 4 and 8) there was no progressive increase over 14 and 10 years.

The first (Case 2) in spite of a rising blood pressure (to 210/105) and the development of an aortic diastolic murmur still had a cardio-thoracic ratio well under 0·5, though there seemed a little rounding of the left ventricle. At 7 years the heart size was 9/19 cm. with a blood pressure of 147/85: at 21 years it was 12·5/29 cm. with a blood pressure of 210/105, so that the general growth of the chest was greater than the increase in the size of the heart (see Fig. 4). In the second (Case 5) there was not even a suspicion of rounding of the left ventricle and the

cardio-thoracic ratio was 0·43 (10·6/24·5 when he was 19 and 11·2/26 when he was 29), although the blood pressure had remained over 180/110 during these ten years (see Fig. 8).

In Case 3 there was possibly a slight increase during the period from 25 to 39 years of age, but it was hardly significant. In the last (Case 6) followed from 13 to 22 years of age it seemed that there was a slight relative increase from (0·52 to 0·56) and that the heart was undergoing slight enlargement as well as natural growth.

On the whole there is no progressive increase in the size of the heart with the high blood pressures of coarctation unless complicating factors arise. No doubt a balance is reached with some increase in the left ventricle, and even this may be absent.

The relative absence of much enlargement is of theoretical interest also, because it is not found so often with other types of high blood pressure, presumably because in these cases the heart is also affected by the associated arterial disease, while in coarctation there is normal heart muscle to deal with the extra work. Graybiel, Allen, and White (1933) found no sclerosis of the arterioles or smallest arteries such as characterizes essential hypertension, and this probably applies to the coronary arteries also. These facts support the view that the importance of high blood pressure (and of valvular disease) in producing cardiac hypertrophy has been exaggerated: the size of the heart is also greatly influenced by whether the muscle is healthy or not and this helps to explain why the size of the heart is in most conditions of such great value in prognosis.

Heart Murmurs

The Systolic Murmur. Characteristically, this is loudest to the left of the sternum in the second and third intercostal spaces. It may or may not be widely transmitted, but is nearly always heard in the back towards the left side, a point that was recognized early (Fawcett, 1905). Sometimes there is a systolic thrill. In small children this systolic murmur may be the only physical sign noted and then other evidence of coarctation, especially the poor femoral pulse, should be searched for. When the collateral circulation is well-developed systolic murmurs may be heard very widely, but some of these may be produced in the tortuous and dilated arteries.

A systolic murmur was noted in all these patients when they were first seen, but the two youngest were already 7 and the next youngest was 13 years. In one (Case 13) the systolic murmur was rather faint and insignificant and in two others it became so—in one naturally (Case 5) and in one after operation (Case 10).

Diastolic Murmurs. A diastolic murmur was heard at the base of the heart in 6 of our 15 patients: in one (Case 1) it may have been due to rheumatic aortic incompetence and in another (Case 2) without any obvious signs of infection it developed and gradually became more obvious, but without any fall in the diastolic pressure when he was between 10 and 14; in the other four it was noted when they were first seen at 13, 17, 17, and 25 years of age respectively, and the readings of the blood pressure were 210/80, 200/90, 195/100, and 170/105 (average 194/94). Perlman (1944) reported it in 9 of 13 cases but this seems a higher proportion than usually.

A high diastolic pressure is the rule in coarctation, even in most cases when there is an aortic diastolic murmur. It is only when there is a greater degree of aortic incompetence caused by superadded changes in the valves that the diastolic pressure is low: these may be rheumatic or other inflammatory or atheromatous changes. Thus in Case 1, with rheumatic aortic incompetence the diastolic pressure was at first 60 and later 45 mm. If the diastolic pressure is low infection of congenital bicuspid valves may often be suspected. Usually the diastolic pressure is relatively high even when there is a diastolic murmur. This probably means a slighter leak from atheromatous changes in bicuspid valves or perhaps even from some stretching of the aortic ring and it will be interesting to see if any of these diastolic murmurs disappear with surgical correction of the coarctation.

The Electrocardiogram

Lewis (1933) stated that there was generally left-sided preponderance: 6 of his 8 cases showed it but 5 of them were over 40 and the 2 who did not were younger—24 and 37 years of age. Brown (1939) considers there are no characteristic changes and that normal axis deviation is often present though left axis deviation generally develops.

Of our 13 patients with cardiograms Case 1 developed left from some right axis deviation in the six years of observation, but as this and the increase in size of his heart may have been the effect of his increasing rheumatic aortic incompetence it is hardly fair to include him. Only 3 of the other 12 had left axis deviation—Cases 3 (25–37), Case 4 (17), and Case 7 (36)—the figures in brackets giving the ages at the time they were under observation. One, Case 2 (7–20), had well-marked right axis deviation. The remaining 8 had no axis deviation but it is of course possible they may develop it as they are all under 33 years of age.

It is, however, obvious from these figures that the electrocardiogram is of no value for diagnosis, as normal is more common than left axis deviation. The rounded left ventricle in radioscopy gives a better indication of the extra work put on the left ventricle, even when there is not enough enlargement to make the total measurements outside the normal range. The cardiogram is, of course, of interest and may be helpful in deciding on the presence of other abnormalities.

Other changes in our cases were T I, T II, and T III inversion (Cases 6 and 7), T 1 inversion (Cases 1 and 4), a biphasic T I (Case 14), slight widening and notching of QRS (Cases 2 and 15), Q III (Cases 12 and 13), an inverted P III (Cases 7 and 10), a biphasic P III (Case 14), and a prolonged P–R of 0·19 sec. (Case 10), of 0·20 sec. (Case 14), and of 0·22 sec. (Case 12).

The Blood Pressure

All writers agree that, with rare exceptions, the blood pressure in the upper part of the body is raised. Lewis (1933) found high blood pressure present in all his adult cases, and that in general it had no further tendency to rise and only fell terminally or with congestive failure. Often the symptoms seem very slight compared with what might be expected for the degree of hypertension, even where the rise of pressure is known to have been present for years. Our findings are given in Tables I and II. In general we have found the pressure rather variable from visit to visit and we, therefore, attach more significance to average figures, some representing a large number of readings taken over a period. Reifenstein *et al.* (1947) have also commented on the variability and quote a case where reading of 122/80 and 180/85 were recorded. King (1937) quotes some similar cases—238/128 to 178/90 (Flexner), 210/170 to 160/90 eighteen months later (Lichtenberg *et al.*)—but such cases are, of course, quite exceptional. We think the difficulty of measuring the blood pressure in the legs has not been stressed sufficiently. We have found no constancy as to whether it is easier by auscultation over the popliteal or by palpation of the posterior tibial or dorsalis pedis; we have often failed to get a convincing reading, though perhaps later in the same patient it has not been difficult to get a decisive level.

The average figure in our patients was 203/105 in the right arm, though in many we obtained one or more readings about 20 mm. higher than this, and 130/85 in the leg; there were some where we could get no convincing reading of the diastolic pressure in the leg. These figures are very close to those of Lewis (1933)—207/105 in the arm and 116/— in the leg.

Rarely the pressure is much lower in the left arm because the left subclavian has its origin below the coarctation (Bayley and Holoubek, 1940). We have not encountered an example of this but have found three cases where many readings gave a persistent difference presumably due to tortuosity of the arteries or unnatural angles of flow of the blood stream. Reifenstein *et al.* (1947) attribute this difference which was present in many of the cases collected by King (1937) to pressure of the distorted aorta above the coarctation on the left subclavian.

In our Case 3 the figures were 235/118 in the right arm and 220/112 in the left; in Case 13, 165/92 in the right, and 155/92 in the left; and in Case 5, 180/107 in the right and 167/102 in the left, and ten years later 186/120 and 175/110 respectively. All these figures were the average of a large number of readings often by various observers.

TABLE I

BLOOD PRESSURE AND SIZE OF THE HEART IN CASES OF COARCTATION OBSERVED OVER SOME YEARS

Case No. and Sex	Age (in years)	Blood Pressure		Size of Heart		
		Rt. arm	Leg	m.t.d. (cm.)	Chest (cm.)	C–T ratio
1* Male	7	142/70	100/50	11·5	21	54
	10	155/70	95/60	13·5	21	64
	12	157/72	—	(17·0	21·5)†	—
	13	165/60	110/—	15·0	22	68
2 Male	7	147/85		9·2	19	48
	9	159/88		10·0	20	50
	11	176/95	110/60	10·0	21	48
	14	180/100		11·0	24	46
	16	210/110		—	—	—
	21*	210/110	125/—	12·5	29	43
3 Female	25	230/120		14·0	—	—
	28	210/110		13·5	25	54
	38	230/120	120/85	15·5‡	27·5‡	56
	40	240/120		14·5	25·5	57
5 Male	19	180/107		10·5	24·5	43
	29	185/120	115/—	11·2	26·0	43
6* Male	13	210/80	115/90	13·0	25	52
	22	200/85	125/—	15·7	28	56

* With an aortic diastolic murmur.
† During rheumatic pericarditis.
‡ During pregnancy.

TABLE II

BLOOD PRESSURE AND SIZE OF THE HEART IN COARCTATION OF THE AORTA

Case No.	Sex and Age	Blood Pressure		Size of Heart		
		Rt. arm	Leg	m.t.d. (cm.)	chest (cm.)	C–T ratio
4*	f. 17	200/90	140/90	14·5	26	56
7	m. 36	250/120	160/120	15·0	28	53
8	m. 30	190/—	120/—	—	—	—
9	m. 29	230/130	135/? 85	13·0	28	46
10	m. 30	190/110	120/80	12·5	28	45
11*	m. 27	195/100	130/90	14·0	27	52
12	m. 33	195/90	140/—	—	—	—
13	m. 27	165/92	130/—	16·3	31	52
14	m. 18	165/105	—	11·0	27·5	40
15*	m. 26	169/107	110/90	13·5	29	47

* With an aortic diastolic murmur.

The Rise in Blood Pressure

Cases of coarctation are rarely diagnosed clinically in infancy, and this is partly because the pressure does not rise greatly for some years.

Lewis (1933) wrote: "It may seem natural to assume that if high pressure is found in the adult case, it has been present from the first year of life, but experience shows that such assumptions are not without danger: the conclusion that coarctation represents life-long high pressure becomes more and more justified as these pressures are recorded over longer periods. In this series there are records of high pressure extending over 5, 6, 6, 9, 13, 15, and 16 years. We still lack records covering childhood and adolescence."

Lewis (1933) collected the records of some reported cases with readings of the blood pressure, but only four of these were under 20 years. Since then Hunter (1928) has reported a boy of 14 with a pressure of 165/90, Hampson (1931) one of 12 with a pressure of 145/75, and Moncrieff (1931) a child of 6 with a pressure of 150/100. Wilkinson (1932) reported a child aged 4 with a pressure of 150/80 in the arms, a feeble iliac pulse, but no obvious collateral circulation; another, aged 14, with a pressure of 198/135 in the arms, no palpable pulse in the leg, and a well-developed collateral circulation; Sheldon (1932) one, aged 12, with a pressure of 150/100, no palpable femoral pulse, and some collateral circulation; and Rooke (1938) a boy, aged 3, with an arm pressure of 150/85, an absent femoral pulse, and a fairly well-developed collateral circulation but no visible notching of the ribs.

King (1937) made a very complete collection of all the reported cases with readings of the blood pressure and Steele (1941) continued this, both including some additional young cases.

We have found few records of the development of this high pressure, but in Case 2 of Farris (1935) it was 120/80 when he was 9, 142/70 when he was 15, 160/90 at 17, and 166–180/74–90 at 19 years. Schwartz and Tice (1939) describe a boy where it was said to be "normal" at 15, 180 at 18 when examined for life insurance, and 176/107 at 23 years. Steele (1941) reports a case where it was said to be "raised" at 10, and was 220/110 at 33 years.

Two of our cases illustrate this rise of pressure, one especially well as it was observed rising from 7 to 16 years of age when it began to stabilize; in a third case the maximum had certainly been reached by 13 and no change took place in the next 10 years. Of course the variation may be wider than this though we think it unlikely that there is any further rise of pressure after the period of growth is completed.

The two youngest cases in our series were 7 years old when the diagnosis was first made. In both these the pressure gradually increased. In Case 1 it averaged 142/70 in 1932–3, 155/70 in 1935–6, 157/72 in 1937, and 165/60 in 1938 when he was 13 and was lost sight of: the low diastolic was no doubt due to aortic incompetence.

Case 2 was seen originally because of the blood pressure after scarlet fever, though investigations showed no renal changes. In 1933, when he was 7, the pressure averaged 147/85; in 1934–6 it averaged 159/88; in 1937, 176/95; and in 1938, 165/100; in 1940 a single reading was 180/100; in 1942, 210/110; and 1946, when he was 20, 210/105. In this case the pressure rose from 147/85 when he was 7 to 210/110 when he was 16, and then began to stabilize.

None of the other cases were as young as these two when they first came under observation and the pressure already seemed to have risen to a level that has been maintained without much change. In Case 6 the blood pressure was already 210/80 when he was 13 and is 200/85 nine years later; in Case 4 it was 210/87 when she was 17 years old (she died later that year); and in Case 5 it was from 200/120 to 180/107 when he was 19 and 185/120 ten years later.

In the older patients we only have one with a long series of blood-pressure readings over many years; in her it showed no significant change from 25 to 40 years of age, being about 230/120 when she was up and about and 190/100 to 205/110 when she had been resting.

These three cases with no great change in the pressure during ten years agree with Lewis's view that the blood pressure can remain at a steady high level for a great number of years till death or the onset of congestive failure. His cases were older than ours, the two youngest being 20 and 24.

Apart from these individual patients followed over some years we have approached the problem in another way. We have taken the average figure for the blood pressure for each age from all the cases mentioned here, from all tabulated by Lewis (1933), by King (1937), and by Steele (1941), and from our own cases. Where these have been followed for some years with frequent readings of the blood pressure they have been included once for each year of observation and a few other reported cases have been included more than once where the data were available.

With the relatively small numbers available (85 values between 3 and 19) and the great variation the average figures for each year are very erratic but there seems no doubt of their becoming gradually higher. To make the numbers in each group a little larger all cases up to 7 were combined, those aged 8 or 9, those aged 10 or 11, etc., and from these averages Fig. 9 has been constructed. It appears that there is a steady rise from 5 years to 16 or 18 years after which the rate of increase tends to be less steep. We have found no adequate data below the age of 5 years.

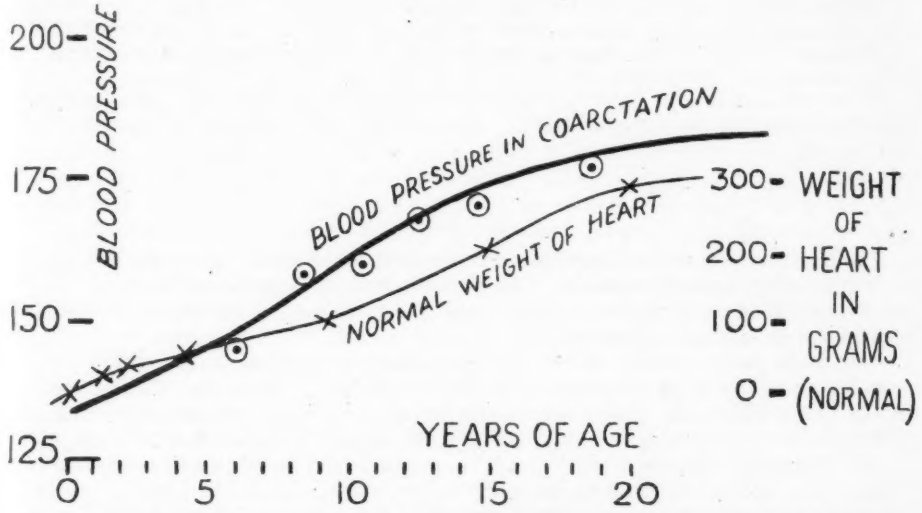


FIG. 9.—Diagram showing the average rise of systolic blood pressure with age in coarctation (see text) and for comparison the average increase of weight of the heart in normal children.

This fits in with the view that the blood pressure rises most quickly during the period of most rapid growth. The increase in the weight of the heart with age has been plotted on the same diagram from the figures given by White (1931). This probably gives a nearer approach to the increase in size of the aorta than the increase of body weight as a whole would, partly because of their closer functional relationship and partly because the heart increases less with age than does the body weight, the heart being 1/130th of the body weight at birth and 1/200th of the body weight in adult life (Quain's *Anatomy*, Vol. II, Part 2, p. 374).

There is some general resemblance between the shape of these two curves, one for the rise of the blood pressure in coarctation and the other for the normal increase in the weight of the heart; and this supports the view that the rise of blood pressure during the period of most rapid growth is because the pathological stenosis of the aorta remains the same size, or does not increase at the same rate as the rest of the aorta. The consequence is that the obstruction

to the circulation becomes greater with a resultant rise of blood pressure and a resultant increase in the collateral circulation.

Lewis (1933) suggested that it had not yet been proved that obstruction was the cause of the raised blood pressure and that such measurements as were available showed that the total area of the main arteries carrying the collateral circulation was much the same as the area of the aorta before the obstruction. If this is true it might be that in a slowly moving stream there would be no rise of pressure. In the arteries, however, the blood is moving with great speed and the pressure depends not only on the total calibre of the vessels but also on the resistance caused by contact with the vessel walls; and the more the main channel is divided into separate arteries and the longer the path, the greater will be the resistance from this point of view.

It seems natural to assume that the high blood pressure proximal to the obstruction is the result of this obstruction. Nevertheless, several writers have suggested since Goldblatt's work on renal hypertension, that this factor is also at work in coarctation. But if such a humoral mechanism were at work it should affect the legs as much as the arms, and the fact that it does not do so or does not do so to the same extent, brings one back to the obstruction as preventing the transmission of the high pressure from above it to the area below it. In so far as there is a tendency for the diastolic pressure in the legs to be high such a humoral mechanism might be responsible, but it seems more naturally related to the small pulse pressure in the legs. This is to be expected from the slow steady flow that takes place into the legs through longer and more devious channels and tends to damp down the usual pulse pressure.

Finally if operative removal of the obstruction is followed by a return of the blood pressure to normal as seems likely from the early reports (Crafoord and Nylin, 1945) this will support the view that the obstruction is the direct cause of the rise.

Prognosis

The possibility of surgical treatment of coarctation of the aorta has emphasized the need for a reasonably accurate prognosis. Fortunately there is evidence on which this can be based—more than we have in the case of patent ductus arteriosus, the relative lack of which have been pointed out by Gilchrist (1945).

The classic paper of Maud Abbott (1928) summarized what was known of 200 collected cases, all supported by the evidence of an autopsy. Of these, 70 per cent died between the ages of 10 and 40, and the deaths were almost equally distributed in these three decades, the mode being between 20 and 30 and the average age at death being just over 30 years.

The causes of death were cardiovascular in four-fifths and from other causes in one-fifth: in more detail, heart failure in 30 per cent; sudden cardiac deaths in under 10 per cent; ruptured aorta and related causes in 20 per cent; endarteritis in 7 per cent; and cerebral hæmorrhage, often from proved congenital aneurysms, in 13 per cent; these making 80 per cent of the total.

Special reported cases might not give a fair impression of the ordinary prognosis but there are two series detailing all those dying in hospital during a long period from 1826 to 1902 in Guy's Hospital (Fawcett, 1905) and from 1909 to 1932 in the London Hospital (Evans, 1933). They not only agree in placing the total incidence at about one case of coarctation in each 1000 necropsies, but also in the average age at death which was 31 in Fawcett's series and 29 years in Evans's series, excluding those of the " infantile " type with multiple congenital defects who died in the first few years of life.

Even these figures, being deaths in hospital, may be considered too pessimistic and it is, therefore, worth considering Bramwell's figures. The average age of his 10 patients who had died was 32, but this figure will be considerably increased as the average age of the 13 patients who were alive was already 35 years. The age of death in Lewis's cases (1933, and Bramwell, 1947, Table X) were older, just over 50, but these were patients who had been fit enough to serve in the army during the war of 1914–18. Bramwell concludes " that patients whose

symptoms date from childhood are unlikely to reach the age of 30, whereas in those who are free from symptoms until the age of 30, the further expectation of life is much more favourable."

As these older patients, free from symptoms up to 30, are less likely to be thought suitable for operation, the other figures are all in rather close agreement that the prognosis of those with symptoms cannot be described as better than fair, with an expectation that on the average life is not likely to be prolonged much beyond 30 years.

It seems, therefore, that successful operative treatment has much to offer, provided the risk is not too great and that the fall of blood pressure found in the early cases proves to be general, as seems likely on theoretical grounds. But the risk of a fatal accident from other congenital abnormalities should not be forgotten, especially from rupture of a cerebral aneurysm, though the fall in blood pressure may help in preventing this catastrophe.

Summary and Conclusions

Coarctation of the aorta still passes unrecognized. It will continue to be missed if a striking collateral circulation is always expected to be self-evident. It will be diagnosed if the femoral pulse is felt for and the blood pressure taken in the legs in every case with high blood pressure or with basal systolic or diastolic murmurs, or with undue pulsation in the neck, when these are without an obvious cause.

The collateral circulation can be demonstrated in many patients when it is not evident, or made more obvious in others, if the patient is made to stoop forward with his arms hanging down vertically while his back is examined in a good light. This is because the greatly dilated subclavian artery is compressed between the clavicle and the first rib: bending forward opens up the costoclavicular space and so releases this pressure on the subclavian artery. Any movement that increases the costoclavicular space may demonstrate this sign.

A high pressure in the arms with a low pressure and a poor femoral pulse, or the demonstration of a collateral circulation are pathognomonic of coarctation of the aorta. They are even more important than notching of the ribs, not only because X-rays are not always available, but because they are present at an earlier age.

The rise of blood pressure, the collateral circulation, and the notching of the ribs develop as a rule between the ages of 6 and 16, but more information is needed about cases at the younger ages. The blood pressure seems to stabilize first, at about 14 to 18, the collateral circulation continues to develop rather longer, and the notching of the ribs still longer.

The rise of blood pressure and the increase in the collateral circulation occur during this period of rapid growth, we suggest, because the stenosis of the aorta does not increase in cross-section (or increases relatively little) with the growth of the rest of the aorta so that the relative obstruction becomes greater.

Average figures for the blood pressure are about 200/105 in the arm and 130/85 in the leg. Thus in the arm there is a greater rise of the systolic than of the diastolic blood pressure. In many cases with an aortic diastolic murmur the diastolic pressure remains fairly high. The relatively normal diastolic reading in the legs is against the view that there is a genuine hypertension following renal ischæmia.

More than half our cases had little or no clinical or radiological enlargement of the heart, though this cannot exclude some small increase of weight and the left ventricle was often rounded. Enlargement was more likely where there was an aortic diastolic murmur (6 of 15 cases) though even then it was sometimes slight. As Lewis found, the heart may not increase in size during many years' observation.

The electrocardiogram is of no value for diagnosis: left axis deviation was present in only a quarter of these patients, aged 7 to 39 years.

The average expectation of life of those with symptoms before adult life is probably no

more than 30 years, so that cure by operation has something to offer. Where the diagnosis is made for the first time in adult life, and especially in those without symptoms, the outlook is relatively good.

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Appendix of Case Notes

Case 1, aged 7 (1932). This boy had whooping-cough and measles and several attacks of bronchitis, and his first school medical examination without comment on his heart. When he was 6, his doctor recorded an aortic systolic murmur. When 7 he was n the Brook Hospital and Dr. Young noted that his murmur had not changed during his attack of scarlet fever and sent him to outpatients with the suggestion that he might have coarctation.

He was found to have a rough aortic systolic murmur and thrill and a soft aortic diastolic murmur, both best heard to the left of the mid-line. A systolic murmur could be heard at the apex also and the diastolic was more rumbling. The blood pressure in the arms varied between 140–160 systolic and 55–85 diastolic, the latter being somewhat difficult to determine at times. In the legs it was 100/50 and the femoral pulses were hard to feel.

There was visible arterial pulsation round the scapulæ and shoulders and rib-notching on X-ray, though this was faint (see Fig. 3). The left ventricle seemed slightly hypertrophied (*see* Table I) and the aortic knuckle was not prominent. The diagnosis of coarctation of the aorta seemed conclusive, though there was some doubt whether he had in addition rheumatic valvular disease (A.S. and A.I., and possibly M.S.) or perhaps regurgitation from bicuspid aortic valves with some added stenosis.

During that winter he had some attacks of bronchitis at home, and when seen in March 1933, had a small right-sided pleural effusion. He made a rapid recovery in hospital and the fluid disappeared in three weeks. The general physical signs were unchanged: the collateral circulation seemed more obvious though pulsation in the femorals and abdominal aorta was still noted.

During the next three years he kept well, but in July 1936, when 11 years old, was readmitted with rheumatic pains, loss of weight, and increasing dyspnœa. Comparing his condition with four years before, the systolic blood pressure and the size of the heart relative to the chest seemed to have increased a little (see Table I). The rib-notching and the collateral circulation were more obvious.

His illness need not be detailed, but after ten days the temperature rose to 104° and continued about 101° F. for five weeks. Rheumatic carditis and infective endocarditis were considered and the former was confirmed by the occurrence of rheumatic nodules and the development of pericarditis with effusion, the transverse diameter of the heart shadow increasing from 14·0 to 17·0 cm. (see Fig. 3). He made a gradual recovery, but from this time onwards he was more breathless and complained of pains in the legs and bronchitis from time to time.

He was last examined in 1938 when he was 13. The apex beat was more heaving and the diastolic murmur was a little louder, both at the base and in the mitral area. The systolic pressure and the size of the heart had again increased a little (see Table I), the pressure in the arms being 165/60 and in the legs 110/?. The rib-notching was slightly deeper and more clear-cut.

In this boy as he grew from 7 to 13 years of age the heart increased in size from 11·5 to 15 cm. with very little increase in the size of his chest or general development. His murmur also increased, but this and some of the increase in the size of his heart may have been due to the complication of his rheumatic carditis. The blood pressure, however, rose from 142/70 to 165/60 (probably with a greater degree of aortic regurgitation) and the signs of the collateral circulation increased, though the rib-notching did not increase so much as in some.

Case 2, aged 7 (1933). This boy was seen because he did not seem to have regained his normal health after two attacks of pneumonia the year before. There was a rough systolic murmur at the base and the blood pressure was 140/90. He was taken into hospital to exclude infective endocarditis or nephritis. There was, however, no pyrexia and the urine was normal.

One of us (S. S.) already wished to diagnose coarctation of the aorta on a poor femoral pulse, some visible arterial pulsation round the scapula, and a suspicion of rib-notching (see Fig. 4). These signs were at this stage so slight that the other was not convinced and wrote that the only certain findings were an average blood pressure of 147/85 and a little enlargement of the left ventricle. A year later, however, this diagnosis was made with certainty as the average pressure was now 159/88 (170/95–150/80) and the collateral circulation was more easily seen.

By 1936, when he was 10, there had been no further increase in the blood pressure or in the size of the heart. His general condition was improved though he was a little breathless if he tried to keep up with the other boys at school.

He was seen frequently during 1937 and many readings of the blood pressure were taken with an average figure of 176/95. The collateral circulation was now more easily visible and palpable: the femoral pulse was very difficult to feel and the pressure in the legs was recorded as 110/60; he had sometimes complained of aching in the legs. Rib-notching was more easily seen on X-ray (see Fig. 4). The basal systolic murmur was rather louder when he was lying than sitting and sometimes a systolic thrill could be felt.

He had been rather undersized but during 1937–9 and the first two years of the war when he was away in Devonshire he grew a good deal and developed generally. The blood pressure still continued to rise to 165/100 in 1939, to 180/100 in 1940, and to 210/110 in 1942. The size of the heart had increased from 10 cm. in 1937 to 11 cm. in 1940.

By 1946, when he was 20, the signs of coarctation were typical and well-developed though he considered himself in good health and was working as a bank clerk. It was difficult to feel any pulsation in the femorals or abdominal aorta and the pressure in the arm seemed to have stabilized at 210/105. The collateral circulation was even more easily seen than four years before and was now visible over the front of the chest as well as along the lower costal margins. The rib-notching had increased and the arterial pulsation in the neck was now much more visible than when he was a boy. The murmurs had increased as well and systolic and diastolic murmurs could be heard both at the apex and at the base with a long systolic thrill at the base. Originally there had only been a rather faint systolic murmur at the base which had gradually increased in loudness and in its area of distribution. The diastolic murmur had developed during 1936–40 (when he was from 10–14) and at first had seemed like a reduplicated second sound at the apex, so that taken alone this simulated the signs of mitral stenosis. The heart had also steadily increased in size from 9 cm. at the age of 7 years, when there had seemed to be some ventricular enlargement only, to 11 cm. in 1940, and to 12·5 cm. in 1946, when there was a general increase in the size of the heart both to left and right, but the relative increase was not as much as the absolute increase, since the chest had also increased with his growth to a greater extent, i.e. from 19·5 to 29 cm. There were no further changes in 1947. He was one of the patients when bending down made the arteries in the back and side, previously only visible under the left scapula, much more obvious and widespread (see Fig. 2).

Case 3, aged 25 (1932). This woman had no complaints till after a stillbirth in her second pregnancy when she was 25. She was then a little short of breath, and was found to have slight enlargement of her heart to the left and a blood pressure of 230/120. She was advised to take some extra rest and to have no more children.

Three years later she was seen again as she had become pregnant, and the correct diagnosis was made. The B.P. was 210/110; the heart was enlarged to the left (13·5 cm. m.t.d. in chest of 25 cm.); and there was forcible pulsation in the neck, simulating aortic regurgitation, and a systolic murmur and thrill loudest at the base of the heart. A collateral circulation was demonstrated over the abdomen and round the scapulæ and there was notching of the ribs on X-ray examination. Her pregnancy continued normally and a living child was born at term.

She left London and was lost sight of till 1944 during the fourth month of another pregnancy. Her general condition had continued to be good, but the collateral circulation was now more striking than before and could not have been missed. The other physical signs were unchanged and the B.P. averaged 230/120 (the same as in 1933), falling to 190/100 when she had been in hospital some days. The femoral pulse was difficult to feel and the B.P. in the legs was 120/85. The heart seemed rather larger, 15·5 cm. m.t.d. in a chest of 27·5 cm., but this was due to displacement owing to the pregnancy (see later and Fig. 6).

The cardiogram showed left axis deviation and was otherwise normal though some records in 1936 had shown some inversion of T III.

She was readmitted for her confinement in May 1945, aged 38, and the average of many blood pressure readings was 235/118 in the right arm and 220/112 in the left arm. Her renal function tests had been normal some months before, but as signs of toxæmia developed a healthy premature infant was delivered by Cæsarean section. Some urinary infection cleared up and she made a good recovery and was discharged home with a blood pressure averaging about 205/109.

In 1947, when she was 40, she was in good health and doing most of her ordinary housework. The B.P. at an outpatient visit was 240/120. The heart was very little larger than in 1935, only 14·5 cm.

in a chest of 25·5 against 13·5 cm. in a chest of 25 cm. The collateral circulation in the back became much more obvious on bending.

In this case, in spite of a blood pressure of 230/120 when she was 25, the patient was in good health when 40, and able to go through a pregnancy when 38 years old. There had been no further rise in her blood pressure and only a slight further increase in the size of the heart.

Case 4, aged 17 (1935). This girl came to hospital because of a hoarse voice, which had been getting worse for some time; it had not been improved by tonsillectomy when she was 10. Pulsation in the neck was noted then and had got worse since she was 14, but she had no other symptoms and had played all games at school. Her heart had not been mentioned till she was 14, though she had been under observation because of her nose and throat for six years.

Mr. Mollison reported that the left vocal cord moved less well than the right. Her face looked bloated and she said that her face and lips often swelled up in the morning. There seemed a large pulsatile swelling low down in the neck on the right side. Because of this and the most unusual degree of pulsation on the right side of the neck it was thought at first that she might have an angioma acting like an arterio-venous aneurysm, but in view of the murmurs and other findings this was probably due to aortic incompetence and abnormal vessels from the right side of the arch (see Fig. 6) with a considerable collateral circulation through the thyroid.

She had systolic and diastolic murmurs loudest in the pulmonary area with a systolic thrill. The heart was enlarged to the left and the B.P. was 220/95 in the arm and 140/90 in the leg. No collateral circulation was seen as she was well-covered but it was easily felt. X-ray showed notching of the ribs, an absence of the aortic knuckle, and an extra shadow above the arch of the aorta below the right clavicle (? abnormal arterial branches).

The right pulse seemed stronger than the left and though the readings were variable they averaged 205/95 in the right and 190/90 in the left arm.

She was seen several times between January and August and said she was well but perhaps a little more breathless. In December she was admitted to St. Olave's Hospital and died in a few days. The diagnosis made was "aortic incompetence and pneumonia," but unfortunately there was no necropsy.

Case 5, aged 19 (1937). This boy had been able to do a good deal without dyspnœa, but for four months had noticed increasing fatigue, especially after gymnastics, and headaches. There was increased pulsation in the neck and the collateral circulation was easily seen. Rib notching was conspicuous.

The blood pressure was sometimes as high as 200/130. The right pulse was felt more easily than the left and the average pressure was 180/107 in the right, and 167/102 in the left arm. The femoral pulse could not be felt. There was no enlargement of the heart (see Table I and Fig. 8). There was a loud systolic murmur at the base, faintly heard towards the apex, but no thrill.

He was seen again in 1947, aged 29. He had passed into the R.A.F. without comment, graded A1, and had served 6 years, mainly doing clerical work in the Middle East, but taking part in all physical exercises and keeping very fit. His heart condition was noted—for the first time in the R.A.F.—and correctly diagnosed on demobilization. His only symptom was tiring too easily after exertion.

The collateral circulation in the back was perhaps less easily seen than in 1937, but over the abdomen it was very striking. The notching of the ribs was a little deeper and more clear cut (see Fig. 8).

As before the right pulse was more easily felt and the pressure was 200–175/120 in the right and 180–170/110 in the left arm. Pulsation could not be felt in the abdominal aorta and barely in the femorals and the blood pressure in the leg was 115/?.

There was no enlargement of the heart and no change in its shape, the bulge in the region of the aortic knuckle being probably due to the enlarged subclavian artery. The systolic murmur at the base was still present, but was fainter and almost insignificant and was certainly much less than ten years before. The electrocardiogram showed no left ventricular preponderance, but slight widening of S in all leads: all T waves were upright though T III had been inverted in 1937. This was another case where bending down increased the collateral circulation and made it much more visible (Fig. 2).

Case 6, aged 13 (1938). This boy was sent to hospital because of the undue pulsation that had been noted in his neck. He admitted to some recent dyspnœa but said that till recently he had been able to play all games without difficulty.

There was striking pulsation in the suprasternal notch and the blood pressure was about 210/80 in both arms and 115 in the legs with a poor femoral pulse. Some collateral circulation was found with difficulty but only over the back; there was slight rib notching.

The heart was just enlarged, and there were loud systolic and diastolic murmurs at the base, so that he probably had aortic regurgitation as well as the coarctation.

He was seen again in 1947, aged 22 years. He was well built and of normal height and had been passed into the Navy during the war without comment. After some months, however, a medical orderly had drawn the doctor's attention to the pulsation in the neck and he had been discharged from the service. He had since worked regularly as an engineer, but admitted to some breathlessness with heavier exertion.

The physical signs were in general the same though there had been some increase. The pulse and blood pressure were the same in both arms falling from 230 to 195/85; it was difficult to feel any pulse in the abdominal aorta or femorals and the pressure was 125. The pulsation in the neck was perhaps even more striking, the collateral circulation was still seen and felt only after a careful search, but it could now be found along the sternal border as well: rib notching was moderate.

The heart had increased in size to 15·7 cm. in a chest of 28 cm. and the enlargement was mainly of the left ventricle (Fig. 5). An apparent aortic knuckle was probably the subclavian artery. The systolic and diastolic murmur at the base of the heart seemed louder and could also be heard at the apex, the former murmur suggesting that perhaps the degree of regurgitation had increased from progressive atheromatous changes, though there was no increase in pulse pressure to confirm this. The aortic second sound seemed accentuated and there was a long systolic thrill at the base. There was also a diastolic shock on palpation in the aortic area.

The cardiogram now showed T I inversion as well as the T II and T III inversion that had been present in 1937. As there was a large R III with no S III it was nearer right than left ventricular preponderance but was really of the R R R type. These findings with the aortic diastolic murmur left some doubt as to what lesion was present as well as the coarctation: in spite of the cardiograms aortic regurgitation seemed the most likely.

Case 7, aged 36 (1940). He was rejected for the Navy at 20 because of his heart. He continued with heavy work although he was a little short of breath. A year before he had been giddy and had become unconscious for an hour—an episode suggestive of a congenital cerebral aneurysm. He was a healthy well-developed man with a little enlargement of the heart to the left, and a fairly loud and widely conducted systolic murmur. There was forcible pulsation in the neck and a poor femoral pulse. The blood pressure was 260/120 in the arms and 160/120 in the legs. Arterial pulsation was clearly felt down the vertebral border of the scapulæ and wide shallow notches were seen in the posterior part of the 3rd to 7th ribs on the right side and the 4th to 9th ribs on the left side. We are indebted to Dr. W. Gover of St. Leonards for details of this case. It has not been possible to trace him.

Case 8, aged 30 (1942). This officer was seen after pneumonia because of a harsh systolic murmur at the base of the heart. The femoral pulse was poor and the blood pressure was 190 in the arms and 120 in the legs. There was a collateral circulation round the scapulæ. X-ray showed no general enlargement of the heart, but, as usual, some rounding of the left ventricle, an absence of the aortic knuckle, and a moderate degree of rib-notching. He complained of no symptoms and has not been seen since.

Case 9, aged 29 (1944). A serving gunner was admitted with a minor pyrexial attack and was thought to have had nephritis as the blood pressure was found to be 220/130. He had led a normal life with no symptoms. We were asked to see him because of the widely distributed systolic murmur. The difficult of feeling the femoral pulse (with a blood pressure in the legs of 135/? 85) pointed to the diagnosis of coarctation and this was confirmed by notching of the ribs on X-ray examination. No other evidence of the collateral circulation was seen, but perhaps it was not searched for thoroughly enough. There was no general enlargement of the heart.

Case 10, aged 30 (1946). A doctor consulted us about his high blood pressure which had been found when he was rejected for life insurance four years before: he thought it had been about 150 and once 170, and rather high (135–140) at 21 at a routine examination as a medical student. He knew he had a systolic murmur since childhood and had not been allowed to play football, but had not been short of breath climbing and had led a normal life otherwise. In 1944 he was rejected for the South African Army because his blood pressure was 175/90 and on one occasion 210: his renal function was fully investigated and found to be normal.

In 1946 the blood pressure was 210–190/110 in the arms and about 120/80 in the legs. (Subsequently, resting in bed before his operation it was 170/100 in the arms and 100/75 in the legs.) There was a rough systolic murmur in the second and third left intercostal spaces, but no thrill: it was also heard in the back. Apart from rib-notching the only obvious collateral circulation was one artery round the umbilicus (which had probably been mistaken for a vein) but arterial pulsation was increased in the neck and could also be felt over the left costal margin and below the right scapula. His heart was not enlarged; the left ventricle was a little rounded, but would probably have passed as normal without comment.

He has since had a successful operation by Dr. Crafoord in Stockholm (October 1946). No details of this are given as he will presumably be reported by Dr. Crafoord. Six months after the operation he was leading a normal life without symptoms and the blood pressure was 160–150/90–85 in the arms and 140–145/? 90–85 in the legs. The systolic murmur had greatly diminished and become quite insignificant. All signs of the superficial collateral circulation had disappeared: he stated that the arterial pulsation round the umbilicus had disappeared within a few days of the operation.

Case 11, aged 17 (1946). A bank clerk was sent to hospital because of the findings at a medical board. He admitted to no symptoms except trifling breathlessness compared with his friends, but his last year at school he had been told there was a murmur and had been stopped playing games. The heart was somewhat enlarged to the left with a rounded left ventricle and with a systolic murmur in the third intercostal space just to the left of the sternum, also well heard in the back, and a diastolic murmur in the aortic area. There was also a very slight systolic thrill at the base. The blood pressure in the arms was 195/100 and 130/90 in the legs. There was striking pulsation in the neck and a collateral circulation round the scapulæ. Radiography showed notching of the ribs and an absence of the aortic knuckle (see Fig 7).

A year later he felt in good health and there was no significant change in the physical signs. The collateral circulation in the back was greatly increased when he bent forward.

Case 12, aged 33 (1946). A Canadian was examined for life assurance before starting work in West Africa. He had led a very active life including boxing, rugger, and ice-hockey without any symptoms, but after completing a battle course in 1943 he was told his blood pressure was too high to continue. In 1946, the forcible pulsation in the neck was very obvious, but the femoral pulse was hard to feel: his blood pressure was 210/95, falling to 185/85 after resting, in the arms, and about 140 in the legs. There was a basal systolic murmur which was also heard in the back, but no thrill was felt. His heart was just enlarged clinically but an X-ray was not available. No collateral circulation was noted, apart from the extreme pulsation in the neck.

Case 13, aged 27 (1946). An ex-soldier, who had served six years and been a physical training instructor part of the time without any symptoms found himself tired in his civilian work as a painter and had occasional headaches. His doctor found a raised blood pressure and referred him to hospital.

Although the blood pressure was 195/105 when first seen, and 165/92 as the average of many readings when he was in hospital, the femoral pulse was hard to feel and the blood pressure in the leg was about 130. X-ray confirmed notching of the ribs with some enlargement of the heart (Fig. 5) and with difficulty some arterial pulsation could be felt (but not seen) below one scapula. He had a systolic murmur at the base (which could be heard in the back also) but no thrill, and a house-physician and presumably the army doctor had not thought it of any special importance. On careful questioning he admitted that he had had pains in the legs during longer marches in the army. He was re-examined a year later. He felt better but there was change in the physical findings. Bending forward demonstrated an increase in the collateral circulation.

Case 14, aged 18 (1946). A young man was sent by a recruiting medical board because of a systolic murmur. He had had a successful series of operations for hypospadias, and had been sent to hospital about his heart when 16, but no details were available and he had been allowed to continue his work. He had played games without any undue dyspnœa.

There was a rough systolic murmur at the base with a faint systolic thrill. There was no enlargement of the heart. There was forcible pulsation in the neck and a blood pressure of 165/105 in the arms: the femoral pulse was hard to feel and no blood-pressure reading could be obtained in the legs. No collateral circulation could be seen, but abnormal pulsation could be felt at several points. Coarctation of the aorta was diagnosed and he was placed in Grade IV.

A year later, to our surprise he was found serving in a parachute regiment and was carrying out his duties without symptoms. No enquiries were made as to how he had joined the army. The physical signs were much the same and the blood pressure was 170/110 in the arms and could not be obtained in the legs. Bending down showed up the collateral circulation well. X-ray examination showed a high degree of notching and scalloping of the ribs (see Fig. 7) and confirmed the absence of any enlargement of the heart though the left border was a little rounded.

Case 15, aged 26 (1947). This man served in the Navy without symptoms, but was told there was something the matter with his heart when he was demobilized. He was sent to hospital by his factory doctor because of an aortic diastolic murmur. He had a systolic murmur to the left of the sternum with a systolic thrill best felt above the clavicles and a soft aortic diastolic murmur to the right of the sternum. His heart was not enlarged and the B.P. was 160/105. He had never complained of any symptoms but said that when he was about 9 years old there had been some comment on his heart at school.

For some reason he escaped X-ray examination and, although the raised blood pressure with a relatively high diastolic pressure without any enlargement of the heart, together with a poor femoral pulse, made coarctation seem likely, rheumatic aortic incompetence and stenosis was thought possible because no evidence of a collateral circulation was found (this was in 1946 before Cases 10–14 were seen).

A year later in discussing the possibility of coarctation, we demonstrated that no collateral circulation could be seen in his back when he was standing erect, but that as soon as he bent forward many small arteries stood out and became most obvious over the back and sides of the chest wall (Fig. 1). An X-ray film then confirmed the diagnosis by showing deep notching of several ribs. The heart was not enlarged (m.t.d. 13·5 cm. in a chest of 29 cm.). The blood pressure varied between 185/120 and 155/95 in the arms and 110/90 in the legs.

MYOCARDIAL TUBERCULOSIS WITH PAROXYSMAL VENTRICULAR TACHYCARDIA

BY

ROBERT SCHNITZER

From the Essex County Hospital, Wanstead

Received April 4, 1947

Tuberculous myocarditis is extremely rare, and even in tuberculous pericarditis it is uncommon. The reason for this is difficult to explain. Since the lungs are a common site of tuberculous infection, one might expect myocardial infection to occur much more frequently. It has been suggested that the constant movement of the musculature is not conducive to the lodgement of tubercle bacilli or to the development of tubercles, and that the lactic acid produced by cardiac muscular activity offers some protection against Koch's bacilli (Raviart, 1906). The following unusual case is reported.

Case Records

A Petty Officer in the French Navy, aged 32, was admitted to hospital in August 1945. He looked extremely ill and slightly cyanosed and complained of severe breathlessness and palpitation.

History. He had always enjoyed good health. In 1940, during the evacuation from Dunkirk, he was wounded in the left forearm and subsequently the whole limb had to be amputated and he was fitted with an artificial arm. Soon afterwards he began to complain of tiredness and shortness of breath on the slightest exertion and this was followed by attacks of palpitation. These attacks started and stopped abruptly, and were accompanied by severe dyspnœa, an aching sensation in the amputation stump, and occasionally by slight hæmoptysis. He had lost 12 lb. in weight within five months and was sent to a sanatorium for further investigation. X-rays of his chest suggested some infiltration in both lungs but were at first not quite typical of tuberculosis, and repeated sputum examination, including cultures, failed to reveal acid-fast bacilli. A bronchogram showed no abnormality. After his discharge from the sanatorium he experienced a severe attack of paroxysmal tachycardia in which he was admitted to hospital twelve hours after the onset.

Examination. A youthful looking man, ashen-grey and cyanosed, dyspnœic, and sweating profusely. Temperature 99·4° F., pulse very rapid and regular; respiration 36. Neck veins distended; apex beat in sixth interspace 3·5 cm. outside mid-clavicular line; no murmurs. Blood pressure 130/80 mm. No clubbing of fingers. Trachea central. A few bronchitic sounds scattered over both lungs, especially over the right mid-zone. Liver not enlarged; spleen not palpable; no œdema.

Progress. Quinidine, intramuscularly and orally, and carotid sinus pressure failed to stop the paroxysm and acute pulmonary œdema developed. Morphine had only a limited effect. A cardiogram during this attack showed paroxysmal ventricular tachycardia (*P.V.T.*) with a ventricular rate of 280–300 a minute, similar but not identical with the paroxysm shown later. X-ray of the chest suggested infiltration in the right lung, and to a lesser degree in the left, and some enlargement of the paratracheal gland. Intravenous injection of 0·5 mg.

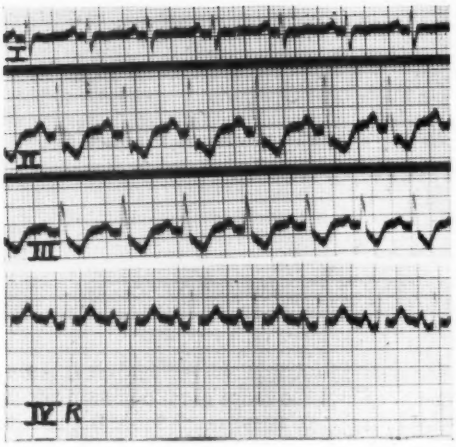

FIG. 1.

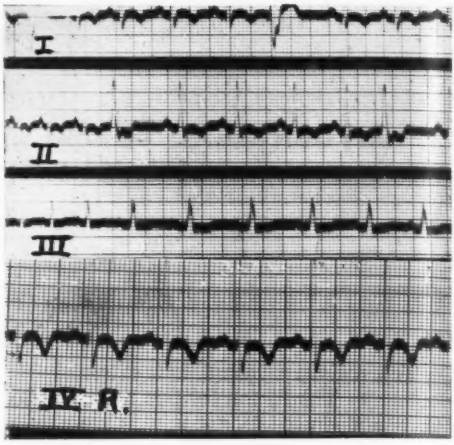

FIG. 2.

FIG. 1.—Electrocardiogram after a paroxysm that lasted 36 hours. Tachycardia ceased after injection of 0·5 mg. digoxin intravenously. Changes suggest myocardial infarction of T III type, or possible effect of recent paroxysm, or of digitalis.

FIG. 2.—Two weeks later. Changes suggest myocardial infarction of T I type.

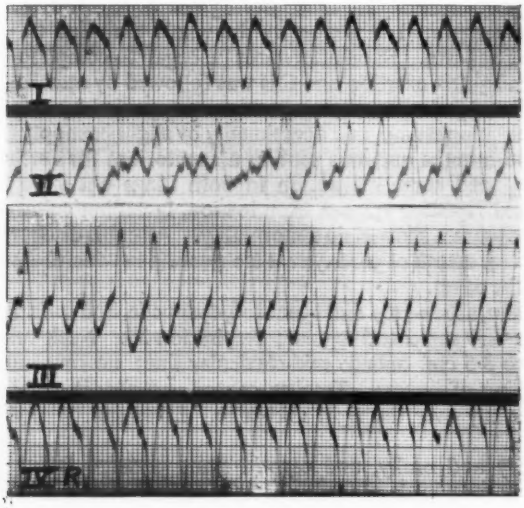

FIG. 3.

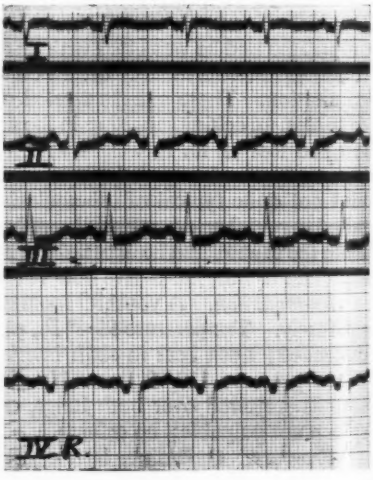

FIG. 4.

FIG. 3.—Paroxysm of ventricular tachycardia that lasted 5 hours.

FIG. 4.—Ten days before death. Changes seen in the previous tracings have almost completely subsided.

digoxin reduced the apex rate to 120, and within one hour a further drop to 108 was observed. Digitalis was continued by mouth in small doses and only a few short attacks of *P.V.T.* occurred, but after four days it had to be stopped because of frequent extrasystoles. Cardiograms between the attacks showed transient T wave changes which might have been attributed to pulmonary infarction, to posterior cardiac infarction, to the effect of the paroxysmal tachycardia, or to digitalis (Fig. 1). Later, however, inversion of the T I suggested anterior cardiac infarction (Fig. 2). One night he complained of weakness and a sinking feeling, and tachycardia recurred and persisted until death early the next morning. A record of one of his paroxysms of ventricular tachycardia is shown in Fig. 3. A cardiogram taken only ten days before his death showed none of the changes seen in previous tracings (Fig. 4).

Investigations. On admission, white blood cells, 27,700, with 89 per cent polymorphs; 10 days later, 5600, with 71 per cent polymorphs. Blood sedimentation rate on admission, 25 mm. in one hour (Westergren); 3 weeks later 10 mm. in one hour. Blood urea 35 mg. per 100 ml. Wassermann and Kahn negative. Urine, slight traces of albumin with many pus cells; culture sterile. Sputum, tubercle bacilli not found; culture for tubercle bacilli negative.

FIG. 5.—Section showing giant celled nodules in myocardium. Magnification: ×52.

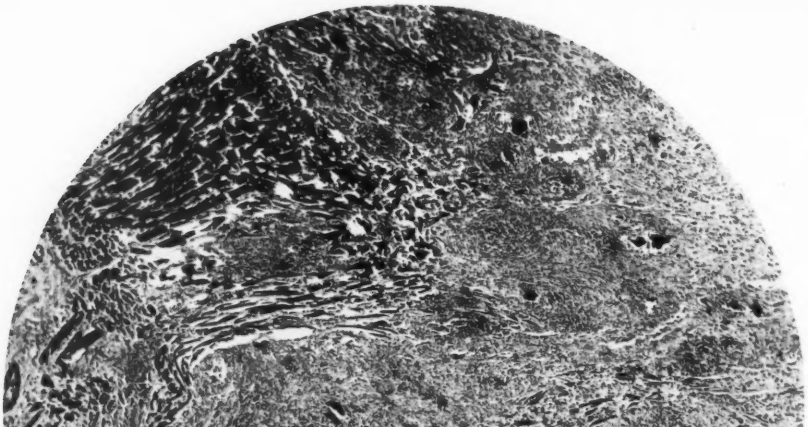

FIG. 6.—Section showing confluent caseous tuberculosis, and miliary foci between the lower myocardial fibres. Magnification: ×52.

POST-MORTEM EXAMINATION

Heart. There was a small amount of straw-coloured pericardial effusion, but no evidence of pericarditis. There was some enlargement of the heart with slight hypertrophy of the right ventricle. There were multiple greyish and yellowish-grey patches throughout the surface of both ventricles; some had a fibrotic appearance and varied in size from a pea to a shilling. More than half of the anterior wall of the left ventricle was replaced by a uniformly yellowish-grey material which extended upward to the aorta, and the interventricular septum showed two similar smaller lesions. The right coronary artery was patent and free from atherosclerosis, but the anterior descending branch of the left coronary artery was imbedded in yellowish-grey material throughout most of its length and its lumen was almost entirely occluded, though there was no thrombosis. All the valves were normal.

Lungs. Paratracheal gland enlarged and firm, the cut surface granular and translucent, its tissue destroyed. There were white patches extending upwards to the lower part of the trachea and downwards into the main bronchi. Multiple greyish-green patches were scattered throughout both lungs, especially in the upper zones. No cavities were seen.

The spleen was enlarged and soft, with multiple irregular greyish patches on the surface and in the parenchyma. The liver was not enlarged, but showed similar lesions and a few dark hæmorrhagic areas. Kidneys and adrenals were normal.

Histological report. Sections of the lung show numerous miliary and confluent tubercles with central caseation in some. Fibrosis is present within and around some isolated tubercles and is marked in the confluent areas, some of which are reduced almost to hyaline scars. Tuberculous arteritis is present in one small branch of the pulmonary artery. The remainder of the lung parenchyma shows œdema and congestion, and alveoli are occupied by an eosinophil coagulum containing free macrophages. A bronchial gland consists of an acellular mass of collagen, enclosing patches of amorphous débris and cholesterol crystals and surrounded by a capsule of fibrotic granulation tissue containing miliary tubercles.

Blocks from the left ventricle and interventricular septum of the heart show similar miliary and confluent miliary tubercles in the myocardium with fibrosis within and around the tubercles. In the left ventricle, fibrous granulation tissue containing tubercles replaces the outer part of the myocardium for a depth of at least 1 cm. except for a few included groups of muscle fibres (Fig. 5 and 6). Inflammatory infiltration is slight in this confluent area, and consists of macrophages, lymphocytes, plasma cells, and a few neutrophil leucocytes.

The dark areas in the liver proved to be cavernous hæmangiomata and in one section measured up to 1·5 cm. in diameter. The remainder of the liver in sections shows albuminous degeneration of the parenchymal cells and scattered miliary tubercles, one having a caseous centre. The spleen shows miliary and confluent miliary tubercles involving Malpighian bodies. The kidneys show albuminous degeneration of the tubular epithelium.

The tubercles in the lung, liver, spleen, and myocardium are composed of collagen, epithelioid and multinuclear giant histiocytes, fibroblasts, and a few lymphocytes. In many tubercles, most or all of the cells are necrosed, and in some the necrosed cells form a homogeneous caseous mass. Caseation affects only a part, usually central, of a tubercle. The giant cells are variable in appearance; some are typical Langhans's cells, but others are more of the foreign body type in that the nuclei, of which there are as many as 40, are scattered and chiefly central. In all sites some giant cells contain eosinophil, crystalloid, star-like, radial cytoplasmic inclusions similar to, but probably not so well developed as, those in the Stengel-Wolbach disease. Acid-fast bacilli could not be found in spite of prolonged search. The presence of caseation in many of the tubercles indicates almost certainly that the condition is tuberculous. The absence of tubercle bacilli might be expected in a tuberculous inflammation of such low grade intensity as was evident in this case.

Discussion

In the case described, the diagnosis of myocardial tuberculosis is established beyond doubt by the histological findings, despite the absence of tubercle bacilli from the sputum and from tissue sections. The route of infection is difficult to explain in the absence of pericarditis, though the lesions in the paratracheal gland, the bronchi and lungs, suggest a primary lymphatic spread. The tubercle bacilli may have gained access to the venous blood stream via the lymphatic duct, then infected the lungs and eventually entered the general circulation via the pulmonary capillaries, whence the myocardium, liver, and spleen became involved.

A case of myocardial tuberculosis was reported by Townsend (1832) who described " a tumour-like auricular growth." In Anders's (1902) extensive review of the subject, the total of reported cases was brought up to 72. From the time of Bollinger's report in 1890 and Raviart's study in 1906, 101 cases had been observed over a period of 16 years, while only 79 cases had been recognized previously. Norris (1904), in a study of 1764 hearts of tuberculous subjects, observed only 6 cases.

Tuberculosis of the myocardium is almost invariably secondary to a tuberculous focus

elsewhere. In the pathogenesis of this disease, three possible routes of infection have been considered, (*a*) by the blood stream, (*b*) by retrograde lymph extension, and (*c*) by contiguous tissues. Myocardial involvement is usually secondary to tuberculous pericarditis. Caseous tuberculous mediastinal lymph nodes, particularly the bronchial or paratracheal group, may be the source of infection of the pericardium and heart. Infection may occur by means of direct contact or through the lymphatics; this latter would necessitate a reversal of the lymph flow, since the drainage of the pericardium has been shown to be upwards into the bronchial lymph nodes (Recklinghausen, 1885). Another possible mode of spread is by direct extension from the pleura.

Three types of myocardial tuberculosis are usually recognized, the nodular, the miliary, and the diffuse infiltrating form. Raviart described a fourth type which he called " chronic interstitial tuberculous myocarditis "; this included the so-called " sclerosis of the myocardium." The existence of this last form has been disputed and it is generally held that fibrous myocardial lesions which may be found in the hearts of those dying from tuberculosis are not necessarily of tuberculous origin. Some such cases, in which tubercles or tubercle bacilli have been found in sections, probably belong to the diffuse infiltrative form of myocardial tuberculosis. The nodular variety is the commonest, and nodules varying from the size of a pea to that of an egg have been reported. Next in frequency is the miliary variety and rarest is the diffuse infiltrative form. According to Moenckeberg (1924), the last mentioned is a " specific diffuse productive tuberculous myocarditis " most frequently a sequel to pericarditis. Here the myocardium appears to be taken up by a uniformly grey or yellow-grey firm material, which may almost entirely replace the muscle in the areas involved. Most authors report that Ziehl-Neelsen staining has failed to reveal tubercle bacilli in spite of typical histological changes. The infiltrating type most often involves the auricles and may cause auricular extrasystoles and rarely auricular fibrillation (Sweeney, 1940). The ventricles are sometimes involved, and occasionally extensive destruction of the myocardium and conducting tissues has been observed. Caseous infiltration may destroy half or more of the thickness of the ventricular wall. Coronary occlusion is seldom observed in cases of tuberculosis, and tuberculous arteritis has been observed very rarely in the coronary arteries where it is usually confined to the smaller branches. In one reported case, however, a comparatively large coronary branch was involved, and, in the present case, almost the whole length of the left descending coronary artery was surrounded and partly occluded by tuberculous infiltration. The initial leucocytosis of 27,700, which disappeared within 10 days, may have been due to the ventricular tachycardia rather than to coronary occlusion; for a leucocytosis of 20,000 to 30,000 which subsides rapidly after termination of the paroxysm may be a feature of paroxysmal tachycardia (Levine and Golden, 1922).

Summary

A case of myocardial tuberculosis complicated by paroxysmal ventricular tachycardia is reported. X rays showed pulmonary infiltration, but sputum tests for tubercle bacilli were negative.

Necropsy showed miliary tuberculosis with extensive involvement of the myocardium, including the interventricular septum, without pericarditis. The tuberculous nature of the lesions in the heart and other organs was established by the histological findings, which are described.

The publications relating to tuberculous myocarditis are briefly reviewed and the pathology is discussed.

I wish to thank Dr. O'Brien and Dr. J. Gilmour for their detailed histological report, and Dr. M. Brown and Dr. D. Gutman for their assistance at the necropsy. I am also indebted to Dr. John Parkinson and Dr. J. W. Linnell for their interest and help, and to Dr. P. J. W. Mills, Medical Superintendent, Lister Emergency Hospital. Hitchin, for permission to publish this case.

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ABSTRACTS OF CARDIOLOGY

Cardiovascular Catheterization as an Aid in Diagnosis of Abnormal Cardiovascular Communications. A. J. GEIGER, H. C. ANDERSON, A. W. WINKLER, and H. S. KAPLAN. *Con. Med. J.*, **10**, 895–899, Nov., 1946.

These authors have applied cardiovascular catheterization to the study of cases of suspected arteriovenous shunts and cardiac septal defects. In their interesting paper they give a preliminary account of the procedure in 16 patients. Their method is that used by Cournand and Ranges since 1941 in the United States. Detailed results obtained by this investigation in 5 cases of suspected abnormal cardiovascular communications are given.

The intracardiac catheterization permits: (1) direct visualization of the septal defect when the tube passes through the defective septum and into the left heart chambers and their vessels; (2) localized injections of contrast media, such as " diodrast " in 70% concentration injected with utmost speed and in volumes of 20 to 40 ml.; (3) direct-pressure measurements which will give evidence of the shunt through transmission of the relatively high systemic blood pressure to the pulmonary artery or the right ventricle; and (4) removal of blood for gas-content analyses, especially estimation of the oxygen content in samples of blood collected from the respective right heart chambers and vessels. In cases of interauricular septal defects the diagnosis is unequivocally established by the finding of considerably oxygenated blood in the right auricle and the passage of the catheter into the right inferior pulmonary vein by way of the left auricle (Case 3).

According to the authors, cardiovascular catheterization is a fairly simple and quite safe procedure which can be conveniently performed even in an out-patient department. Except for an occasional local venous thrombosis in the catheterized arm, no untoward effect has resulted. No murmurs were heard on auscultation when the catheter had passed through the tricuspid and pulmonary openings. Attention is drawn to an occasional failure to demonstrate relatively arterialized blood in the presence of a small septal defect; this happens because: (1) a small quantity of arterialized blood is shunted, and (2) the tip of the catheter may be situated out of the line of flow of the shunted blood. *A. I. Suchecki*

Primary Pulmonary Hypertension. J. R. GILMOUR and W. EVANS. *J. Path. Bact.*, **58**, 687–697, Oct., 1946.

Clinical observation in a case of cardiac failure had suggested the diagnosis of pulmonary hypertension, and this was confirmed at necropsy. A woman of 44 had suffered for 2 years from intense fatigue, dyspnœa on slight exertion, and œdema, and had responded to treatment with rest, digitalis, and mercurial diuretics. Diagnoses of hypertensive heart failure and of pericardial disease, respectively, had been made at the 2 hospitals to which the patient had been admitted previously, but the skiagram and the electrocardiogram pointed to a pulmonary-vascular origin of the condition, the first showing enlargement of the right auricle, of the conus of the right ventricle, and of the pulmonary artery, and the latter right ventricular preponderance with an inversion of the T wave in leads II and III and CR_1. Although the patient appeared to be responding well to treatment, she died suddenly.

At the post-mortem examination there was evidence of congestion in lungs, liver, spleen, and kidneys; there were hypertrophy and dilatation of the right ventricle, dilatation of the right auricle, and adherent thrombi in the right auricular appendage, with slight atheroma in the aorta and " many small flecks of atheroma in pulmonary artery and its branches ". The histological examination of the pulmonary vessels showed in numerous sections aplasia or hypoplasia of the media of many vessels, together with intimal changes resembling those of systemic hypertension in these areas, so that stenosis or occlusion of these vessels resulted. The deficiency of the media in numerous vessels throughout the lungs was, in the opinion of the authors, the basis for the development of the endarteritis, which occurred as a reaction to transient hypertension, such as might have been produced by coughing, and thus started a vicious circle which made the hypertension permanent.

B. Samet

Parenteral Vitamin B as Agent for Determining the Arm-to-Tongue Circulation Time. Part I. R. E. SWENSON. *Amer. Heart J.*, **32**, 612–616, Nov., 1946.

A commercial preparation of the vitamin-B complex is used to measure the arm-to-tongue circulation time, 5 ml. of the preparation being injected intravenously through a No. 20 needle; the end-point is given by a sudden, intense, and unique taste sensation. A duplicate determination can be made within a few seconds of the first one and no untoward complications have occurred. *H. E. Hollin*

Tachycardia due to Venous Hypertension in Man. (A Study of the Bainbridge Reflex.) La tachycardie créée par l'hypertension veineuse chez l'homme. (Étude du réflexe de Bainbridge.) J. LEQUIME, M. SEGERS, and H. DENOLIN. *Acta cardiol.*, **1**, 1–13, 1946.

The authors present the results of the following experiments in support of the hypothesis that an

increased venous pressure leads to a rise of pulse rate (Bainbridge reflex) in man, and that this is mediated by the vagus nerve. In the course of the investigations a proportion of the subjects showed an increased respiratory rate when the venous pressure was raised—an effect similar to that observed by Harrison in animals. It is emphasized that the Bainbridge reflex cannot completely account for the cardiac acceleration after exercise.

Eleven subjects were infused with 1 litre of warmed serum over a period of 5 to 10 minutes. The venous pressure was found to rise 12 to 24 mm. of water. Electrocardiographic records taken over the same period showed an increased pulse rate of 8 to 25%. After 4 subjects were given 2 mg. of atropine intravenously the pulse quickened and the venous pressure fell. Infusions were then administered as before without influencing the heart rate, though the venous pressure rose above resting levels. (During the course of all these investigations there was no change of blood pressure as measured by a Pachon oscillometer.) In a case of femoral anteriovenous aneurysm, compression of the anastomosis gave a fall of venous pressure and pulse rate and a rise of arterial pressure as measured directly by a cannula in the opposite femoral artery. These changes were suppressed after the administration of 1·5 mg. of atropine intravenously. The respiratory rate was observed to increase after infusion in 8 of the 11 subjects. (The vital capacity remained constant.) This effect was not observed when atropine was administered first. It was not seen in the arteriovenous aneurysm. The possibility that some of these effects might be due to transfusion reactions, or to pharmacological substances in the serum used, is not discussed.

W. J. H. Butterfield

Hypertension and Calcium Intake. C. M. KESSON and A. MCCUTCHEON. *Lancet*, **2**, 793, Nov. 30, 1946.

The authors, in the Stobhill Hospital, Glasgow, have studied a group of 80 patients over the age of 40 years to see whether any correlation exists between osteoporosis and arteriosclerosis. In 30 there was evidence of osteoporosis, and in these the blood pressures were similar to those of the control cases, while arteriosclerosis and arterial calcification were present equally in the two groups. In subsequent investigations which entailed a daily calcium intake of 1·6 g. for periods of 6 to 15 months no hypertension developed and arterial calcification did not progress. It is concluded that, contrary to the claim of Harris, a high-calcium diet over many months has no effect on the development of arteriosclerosis.

R. Bodley Scott

Clinical Aspect of Polyarteritis Nodosa. H. G. MILLER and R. DALEY. *Quart. J. Med.*, **15**, 255–283, Oct., 1946.

Though more cases of polyarteritis nodosa than formerly are now being recognized before death, a large proportion are still missed. The authors believe that the difficulty of diagnosis during life is only in part inherent in the behaviour of the disease, and that in many cases it is due either to failure to consider the diagnosis in a difficult case or to rejection of the diagnosis, once considered, because of the absence of one or more signs, such as subcutaneous nodules or eosinophilia, which are considered typical but are actually of infrequent occurrence.

To clarify the clinical picture, so far as is possible in a condition of such protean manifestations, the more important past writings are reviewed and 9 new cases are recorded.

R. T. Grant

Dissecting Aneurysm of the Aorta. (A Study of a Series of Fourteen Cases.) J. D. PALMER and A. K. MATHISEN. *Canad. med. Ass. J.*, **55**, 585–595, Dec., 1946.

Ante-mortem diagnosis of dissecting aneurysm of the aorta is difficult. The patient usually dies of rupture of the aneurysm with a massive hæmorrhage, but occasionally he may survive and organization and obliteration of the sac or rupture back into the lumen may occur with formation of a double-barrelled aorta. The incidence in the Royal Victoria Hospital, Montreal, was 1 in 575 necropsies, compared with 1 in 175 reported by Shennan. There were 7 male and 7 female patients, whose average age was 49 years. Onset of symptoms was sudden and occurred when the patient was at rest: severe pain is felt in the præcordial region or upper quadrants of the abdomen, or, if the dissection involves the abdominal aorta, may spread into the lower abdomen, and it later spreads into the back. Pain is intense, sharp, and tearing and may recur. All patients show marked prostration and signs of shock may be present. In 8 cases the blood pressure was high on admission, while in 8 it was low. Temperature was normal on admission, but in those who survived the temperature rose after the first day to 100°–101° F. (37·8°–38·4° C.). White-cell count and erythrocyte sedimentation rate were moderately raised. In most cases the urine contained albumin, hyaline casts, and red cells. In two cases hemiplegia resulted from involvement of the orifice of the innominate or carotid artery. The Wassermann reaction was usually negative, and the chest radiography revealed widening of the arch of the aorta. Electrocardiograms in 10 cases showed the changes of hypertensive heart disease; where previous records were available no change since the incident could be found. In 1 case electrocardiographic changes like those of coronary occlusion appeared on the tenth day, and necropsy disclosed involvement of the coronary arteries by the dissection, and the presence of blood in the thoracic cavity, usually on the left side. In 2 instances there was blood in the pericardium. The ascending and transverse portions of the arch were most commonly affected. The aorta showed medial necrosis and the heart was hypertrophied in all cases except one. It is considered that hypertension was an important factor in the production of the dissection.

J. McMichael

Hypertrophy of the Heart of Unknown Etiology in Young Adults: Report of Four Cases with Autopsies. R. F. NORRIS and H. H. POTE. *Amer. Heart J.*, **32**, 599–611, Nov., 1946.

Death from congestive heart failure occurred in four instances of unexplained cardiac hypertrophy and dilatation. These 4 unusual cases occurred during 1 year at the Philadelphia Naval Hospital, and the victims were all sailors between the ages of 21 and 30 years. The cardiac hypertrophy was in all cases recognized and investigated some time before death, so that the usual causes of the condition had been excluded. It would have been more satisfying, as the authors point out, if glycogen-storage disease could have been excluded. There was, of course, no indication that the ætiology was the same in all 4 cases.

H. E. Holling

Anoxemia and Exercise Tests in the Diagnosis of Coronary Disease. G. BIÖRCK. *Amer. Heart J.*, **32**, 689–696, Dec., 1946.

This contains a discussion of the value of the various tests designed to elicit anginal pain or electrocardiographic changes in patients in whom the diagnosis of coronary artery disease is in doubt. The general conclusion is that such tests are not to be recommended for general use; their application and interpretation require considerable experience and they are liable to provoke unpleasant reactions. *R. T. Grant*

Notes on the Similarity of QRS Complex Configurations in the Wolff-Parkinson-White Syndrome. G. E. BURCH and J. L. KIMBALL. *Amer. Heart J.*, **32**, 560–570, Nov., 1946.

From a review of the literature the authors conclude that the various configurations of the QRS complex seen in the electrocardiograms of cases of Wolff-Parkinson-White syndrome may be classified into 5 types. The criteria employed in diagnosis were: (1) a short P–R interval and a prolongation of the QRS duration with slurring and notching; (2) absence of any clinical signs of heart disease in most instances; (3) repeated paroxysms of tachycardia; and (4) return of the electrocardiogram to normal on parasympathetic depression and exercise as well as spontaneously. The similarity of types III and IV to left and right bundle-branch block is pointed out, the short P–R interval indicating the correct diagnosis.

The Wolff-Parkinson-White syndrome is due to the existence of an anomalous conducting pathway connecting the auricles to the base of the ventricles. Impulses from the auricles pass down this pathway as well as by way of the auriculo-ventricular node and Purkinje system, but owing to the shorter course of the anomalous pathway the process of ventricular depolarization is initiated earlier in the region around its termination. The site of termination of this pathway is an important factor in the configuration of the electrocardiogram. *B. McArdle*

Electrocardiographic Changes occurring during Treatment with Fuadin Solution. S. B. BEASER and R. RODRIGUEZ-MOLINA. *Amer. Heart J.*, **32**, 634–644, Nov., 1946.

The authors report that 20 of 25 cases receiving fouadin treatment for infections with *Schistosoma mansoni* showed decrease in the voltage of the T waves of the electrocardiogram. These changes were reversible after 3 or more weeks. It is suggested that the drug affects the myocardium, and that courses of therapy with it should be separated by a similar period to prevent cumulative effects on the myocardium.

W. J. H. Butterfield

Orthostatic Paroxysmal Ventricular Tachycardia. M. PETERS and S. L. PENNER. *Amer. Heart J.*, **32**, 645–652, Nov., 1946.

The authors describe the case of a woman, aged 24 years, who for 1½ years had had frequent attacks of tachycardia occurring only in the upright position, always ending when she lay down, and recurring on standing. Electrocardiograms taken during attacks were characteristic of paroxysmal ventricular tachycardia. The relation to posture was confirmed. The authors review the literature of paroxysmal ventricular tachycardia and suggest that in their cases the attacks were due to unusually strong sympathetic tone.

B. McArdle

The Combined Use of Lanatoside C and Quinidine Sulfate in the Abolition of Established Auricular Flutter. R. M. TANDOWSKY, J. M. OYSTER, and A. SILVERGLADE. *Amer. Heart J.*, **32**, 617–633, Nov., 1946.

Intravenous lanatoside C (a glycoside of digitalis) was found to be more effective than digitalis (especially when given by mouth) in the conversion of established auricular flutter to fibrillation. An initial dose of 1·6 mg. given intravenously was followed by a daily maintenance dosage of 1 mg. Twenty-one cases were treated. Of these, 4 reverted to sinus rhythm within an hour: auricular fibrillation was established in 15 within 2 to 72 hours and in 1 case after 13 days' treatment, while in a thyrotoxic patient (before operation) the rhythm was unchanged. In all but 4, primary slowing of the ventricular rate occurred within an hour. Quinidine sulphate with lanatoside C (1 mg. daily) was given to the 15 patients who developed auricular fibrillation. Owing to intolerance the quinidine was discontinued in 1 case; the remaining 14 reverted to sinus rhythm within 1 to 10 days, but flutter recurred immediately the quinidine was discontinued in 1 case, and in 1 other sinus rhythm was followed by nodal tachycardia and sudden death. Necropsy showed an extensive myocardial infarct. The remaining patients received a maintenance dose of lanatoside C over an average follow-up period of 11 months without recurrence of flutter. Lanatoside C is superior to digitalis leaf because of its rapidity of action when given intravenously and its strong vagal action. *B. McArdle*

Electrocardiographic Criteria of Bundle-branch Block and its Location. (Present Position of the Question.) (Les critères électrocardiographiques du bloc de branche et de sa localisation. État actuel de la question.) H. DENOLIN. *Acta cardiol.*, **1**, 44–68, 1946.

This is a good review of the literature of bundle-branch block. The author considers that our present criteria for diagnosis of abnormalities of interventricular conduction may prove hazardous, and that the diagnosis of asynchronous contractions of the ventricles may prove particularly so. He points out that the duration of the QRS complex may be prolonged to over 0·1 second in healthy hearts, and the position of the heart in the chest and the electrical conductivity of the tissues adjacent to it may cause aberrations of the ventricular complex. This being so, he would prefer that electrocardiographs showing a QRS deflexion prolonged over 0·1 to 0·12 second and followed by a T wave of opposite polarity should be judged diagnostic of a " disturbance of intraventricular conduction ", and that the term " bundle-branch block " should not be used because it presupposes a pathological state of the ventricles which may not be otherwise demonstrable. He points out the need for further study of asynchronous contraction of the ventricles. *H. E. Holling*

The Clinical Significance of Certain Changes in the Limb Lead Electrocardiogram in Arterial Hypertension. G. F. FILLEY. *Bull. Johns Hopk. Hosp.*, 79, 261–282, Oct., 1946.

The electrocardiogram of left ventricular strain shows inversion of the T waves in lead I or leads I and II with left axis deviation and high voltage. The significance of this change is still uncertain. The author has analysed the clinical and pathological findings in 100 cases of arterial hypertension with these changes in the electrocardiogram. The electrocardiographic changes become most marked with diastolic pressures over 130 mm. Hg and in the presence of coronary sclerosis. Cases of myocardial infarction were excluded from consideration. When the heart weight is above 500 g. the electrocardiographic change is also pronounced. There was no relation to the predominance of left ventricular over right ventricular hypertrophy as gauged by the ratio of thickness of walls of right and left ventricles or of weights of these chambers.

The electrocardiographic changes in themselves do not indicate a very bad prognosis. The strain pattern reflects primarily the degree of hypertrophy in response to the high diastolic pressure rather than the state of myocardial sufficiency; it does not seem to bear any relation to the duration of the hypertension. The relation of coronary artery disease suggests that the T-wave changes are associated in some way with the myocardial blood supply, and also with hypertrophy. The changes of strain, however, should not be interpreted as unfavourable signs. They are quickly reversed after sympathectomy. *T. McMichael*

The Diagnosis and Treatment of Tracheal and Esophageal Obstruction Due to Congenital Vascular Ring. R. H. SWEET, C. W. FINDLAY, and G. C. REYERSBACH. *J. Pediat.*, **30**, 1–17, Jan., 1947.

Two cases of this rare congenital defect due to a double aortic arch are reported. The infants developed a persistent cough and inspiratory stridor within two weeks of birth. In the first case, radiological examination of the œsophagus with the aid of barium, when the child was 3½ months old, showed an indentation posteriorly at the level of the aortic arch and, slightly below this, another indentation of the right lateral margin of the œsophagus. Surgical exploration confirmed the diagnosis, and the ductus arteriosus and ventral component of the double aortic arch were ligated and divided. The patient made an uneventful recovery. In the second case radiological examination at the age of 2 years showed a displacement of the superior mediastinum to the right and a narrowing of the trachea at the level of the aortic arch posteriorly and on the right. Two years later, radioscopy with barium showed an œsophageal deformity at the same level. At operation a vessel representing a persistent right fourth aortic arch connecting the ascending and descending aorta was identified, ligated, and divided. The subsequent progress of the child was satisfactory. *Jas. M. Smellie*

The Effect of Anticoagulants on the Penicillin Therapy and the Pathologic Lesion of Subacute Bacterial Endocarditis. W. S. PRIEST, J. M. SMITH, and C. J. MCGEE. *New Engl. J. Med.*, **235**, 699–706, Nov. 14, 1946.

It has always seemed logical to use anticoagulants in the treatment of subacute bacterial endocarditis in order not only to prevent the formation of fibrin deposits and to make bacteria more accessible to therapeutic agents but also to diminish the frequency of embolism. This communication concerns 34 consecutive cases of bacterial endocarditis treated with penicillin at the Wesley Memorial Hospital, Chicago. Of these, 15 received in addition heparin or dicoumarol, either alone or in combination, and 19 were treated without anticoagulants. In the entire series there were 12 deaths; 8 of the patients had received anticoagulants at some period of their treatment. The authors found that the use of anticoagulants did not always prevent major embolism, and that there was no quantitative difference in the amount of fresh fibrin on the lesions whether anticoagulants had been given or withheld. Heparin proved an expensive treatment, not only from its intrinsic cost but also because of the necessary daily tests of prothrombin time. The important conclusion reached was that, if the daily dose of penicillin is adequate, healing will take place as well without, as with anticoagulants. All 15 of the latest cases recovered with 1,000,000 units or more of penicillin daily. Anticoagulants may have been responsible for fatal hæmorrhage in 2 cases. *James W. Brown*

Paroxysmal Hypertension. A. S. ROGEN. *Lancet*, **1**, 103, Jan. 18, 1947.

As evidence that paroxysms of hypertension may be caused by a rapidly growing cerebral tumour, even when it does not invade the thalamus or hypothalamic region, the author records the case of a man of 62 with a few weeks' history of epileptiform attacks, whose origin from a right cerebral focus was shown by twitching of the left arm and leg followed by left hemiparesis and aphasia. There had been no significant headache, giddiness, or papillœdema, but the blood pressure had fluctuated between wide limits (260×/140 and 110/70 mm.), the higher reading being associated with his epileptiform attacks, though it was occasionally unrelated to these. Apart from an apparently positive cold pressor test (Hines, *Amer. Heart J.*, 1940, **19**, 408) there was no evidence of an adrenal medullary tumour (phæochromocytoma), though this diagnosis had been seriously enough considered for laparotomy to be contemplated. At necropsy a large glioblastoma was found occupying the right parietal and occipital lobes; this did not encroach on the thalamus or hypothalamus. No adrenal tumour was found.

Henry Cohen

2-Thiouracil in the Treatment of Congestive Heart Failure. E. P. SHARPEY-SCHAFER. *Brit. med. J.*, **2**, 888–889, Dec. 14, 1946.

The theoretical purpose of thyroidectomy in congestive heart failure is to reduce the total oxygen requirements of the body and so decrease the work of the heart. As a means of avoiding the high mortality associated with thyroidectomy in severe cases of cardiac failure the author tried the effect of 1 to 2 g. of 2-thiouracil given over long periods. Detailed results of the treatment of 12 cases are presented.

By means of cardiac catheterization the cardiac output and right auricular pressure were measured, and the work of the heart was calculated arbitrarily from the product of the cardiac output and the blood pressure. Seven cases of low-cardiac-output heart failure (hypertension and valvular heart disease) and 5 cases of high-cardiac-output failure (emphysema) were treated, and, as several had already received a long period of treatment by ordinary methods, spontaneous improvement was considered unlikely. It was found that the basal and resting oxygen consumption were reduced by thiouracil, but it did not follow from this that the cardiac output necessarily fell, as sometimes the arteriovenous oxygen difference decreased with the fall in oxygen consumption. Since the blood pressure sometimes remained unchanged it follows that the work of the heart may be unaffected by thiouracil. Even so, clinical improvement, as judged by a fall in venous pressure and an increase in exercise tolerance, resulted in both groups in the majority of cases. It is pointed out that no benefit can be expected in rapidly deteriorating patients, as thiouracil takes a week or 10 days before its effect on the thyroid is evident.

S. Oram

The Present Status of Penicillin in the Treatment of Subacute Bacterial Endocarditis. H. E. RYKERT. *Canad. med. Ass. J.*, **55**, 543–547, Dec., 1946.

Fifteen patients with subacute bacterial endocarditis treated with penicillin in the Toronto General Hospital are reported; in 5 the disease was clinically arrested, 5 died of complications (nephritis, 1; emboli, 3; and congestive failure, 1), but in these the infective process was probably arrested, while in another 5 the treatment failed. In one of the failed cases the cause was probably an insensitive strain of streptococcus, but in the others it was difficult to determine the cause of failure. A daily dose of less than 200,000 units is likely to be inadequate. If the response to this is unsatisfactory (blood cultures remaining positive, fever persisting) the dose should be increased to 500,000 units daily. There is little to be gained by any increase above this dosage. The average duration of the disease in the clinically arrested cases was 8 weeks, compared with 23 weeks in the cases in which the treatment failed. Long duration of the disease leads to deep location of the organisms in the vegetations. Either continuous intramuscular drip or interrupted injections are suitable.

J. McMichael

The Esophageal Electrocardiogram in Arrhythmias and Tachycardias. C. BUTTERWORTH and A. C. POINDEXTER. *Amer. Heart J.*, **32**, 681–688, Dec., 1946.

This paper emphasizes the value of the œsophageal electrocardiogram in aiding accurate diagnosis in certain cases of tachycardia and arrhythmia. It is of special value in those abnormalities in which the P waves are difficult to identify accurately—as, for example, when the P wave is superimposed on the ventricular complex or when P-wave voltage is low. Illustrative electrocardiograms are given. The construction and use of œsophageal electrodes are briefly described.

R. T. Grant

Electrocardiogram in Derangements of the Organism's Water and Electrolyte Metabolism. [In English.] O. J. BROCH. *Acta. med. Scand.*, **126**, 157–176, Nov. 9, 1946.

Electrocardiograms were taken on 18 patients with well-marked dehydration or disturbance of acid-base or electrolyte balance. Dehydration (determined clinically or by changes in hæmoglobin concentration) was usually associated with a depression of the S–T interval in one or more leads, but there was no correlation between the degree of this depression and the severity of the dehydration. The S–T interval became isoelectric on restoring the fluid balance, but the T waves usually became temporarily flattened or diphasic for 1 to 3 weeks. The author believes that these changes were due to an inadequate coronary blood flow secondary to the dehydration. Potassium chloride given as a 25% solution to 4 cases of renal insufficiency caused a rise in the height of the T waves when these were positive, or a smaller deflection when negative.

B. McArdle